

Comparative Analysis of Lead Rubber Bearing And Friction Pendulum Bearing: A Review

Pagdiwale Sohail Sadique¹, Ajay Dahake²

¹ PG student, Dept of Civil Engineering

² Professor and HOD, Dept of Civil Engineering

^{1,2} G H Raisoni College of Engineering and Management, Wagholi, Pune

Abstract- Base isolation approach has become a critical segment to improve unwavering quality during a seismic earthquake. In now day by day's base detachment has become a relentlessly applied essential arrangement technique for structures and frameworks in significantly seismic zones in all viewpoint. The generally used separation system is Lead Rubber Bearing, Laminated Rubber Bearing and Friction Pendulum, channel Method, Pile Method and Damper part. Base separation is one of the most present ay strategy and broadly acknowledged seismic insurance framework utilized in the structure in Earthquake inclined territories. The base detachment framework isolates the structures from its establishment and essentially moves it comparative with that of the super structure. The objective of this project is to comprehend the seismic exhibition of a G+10 unpredictable structure made of three distinct materials, for example, RCC, Steel and Composite with Lead Rubber Bearing (LRB) and Friction Pendulum Bearing (FPB) base isolation framework and to contrast the seismic reaction and without base isolation utilizing Response spectrum method in ETABS-2015 software. The reaction of the structure, for example, time period, base shear, story drifts and story displacements are studied and comparison is made. From this study it can also be concluded that it is better to provide isolation systems in seismic prone areas rather than providing fixed base and among two isolators used here FPB performs better than LRB for all the structures.

Keywords- RCC, steel, Composite structures, Response spectrum, ETABS 2015.

I. INTRODUCTION

Earthquake are the normal calamity that happens because of the moving of plates or plate tectonics in earth's outside layer and has ended the lives of a large number of individuals all through the ages. These powers are exceptionally solid and stay for a brief length of time. In the earthquake plan of little and medium story structures, the quake power is a lot more prominent than the essential recurrence of vibration which means building goes about as an intensifier and the quickening experienced at each floor

increments to the top. So the anxieties and understory floats increments in the part and the section gets harmed between the floors. At times the increasing speed makes more harm the substance and inhabitants of the floors without making more harm to the structure. The increasing velocities can be diminished by making the structure progressively adaptable. Be that as it may, adaptability makes a few issues in the structure, for example, it makes breaks in the parcel dividers and windows may fall because of high wind power. Therefore in low to medium ascent structures the most ideal approach to accomplish adaptability is by utilizing base-seclusion technique. Consequently the use of adaptable gadgets in the flat bearing in the base of the structure lessens transmission of extreme seismic earthquake ground movements into the superstructure. In this manner to accomplish the wellbeing of structure against quake, there is a need to expand the seismic limit (obstruction) of the structure and to diminish the seismic interest (powers) on the structure. The sidelong quality and the horizontal solidness are the fundamental prerequisite of the seismic opposition. Specialists are required to choose a proper basic framework to oppose the parallel powers together with the gravity power, inside the useful and engineering imperatives. It is particularly fundamental that all the sidelong burden opposing auxiliary segments should be inflexibly associated. The seismic interest on the structure can be diminished by seismic change seclusion. The essential head of seismic separation is to adjust the reaction of the structure to allow the dispersals of vibration vitality or by base detachment. The fundamental guideline of base confinement is to lessen and control vibrations incited from seismic earthquake on any structures. The detachment framework diverts through the elements of the framework yet it doesn't ingest the vitality. In this undertaking "in addition to" formed arrangement sporadic structure is considered and here two kinds of base confinement frameworks are thought of one as, is Lead Rubber Bearing (LRB) and the other one is Friction Pendulum Bearing (FPB) base seclusion framework .

1.1 Base Isolation Concept

The idea of base isolation is to disconnect the structure starting from the earliest stage such a way, that seismic tremor

movement are not transmitted up through the structure or possibly enormously decreased as appeared in Fig. 1. In the event that the structure is made to lay on adaptable cushions that offer safe against parallel development, at that point some impact of the ground shaking will be moved to the structure above. On the off chance that the structure adaptable cushions are appropriately picked the power actuated by ground shaking can be a couple of times littler than that accomplished by the structure manufacture legitimately on ground.

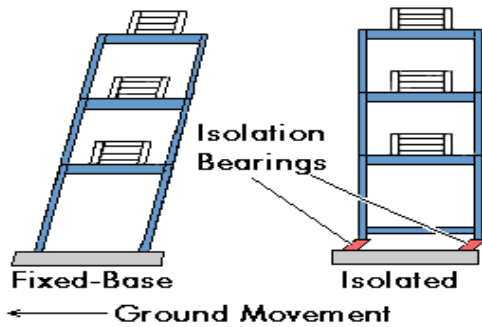


Fig. 1: Structure with and without base Isolation System.

1.2 Techniques of Earthquake Resistance

- Lead Rubber Bearing Mechanism
- Laminated Rubber Bearing approach
- Rubbing Pendulum System Mechanism

Lead Rubber Bearing Approach

LRB consists of three main pieces of equipments, i.e. layers of steel plates, rubber layers and lead core. Same as the steel shims in natural rubber bearings, the layers of steel provides vertical stiffness and the layers of rubber supply the device with high lateral flexibility. Lead center is the gadget that will supply additional firmness to the isolators and proper damping to the framework. LRB bearing is shown in Fig. 2.

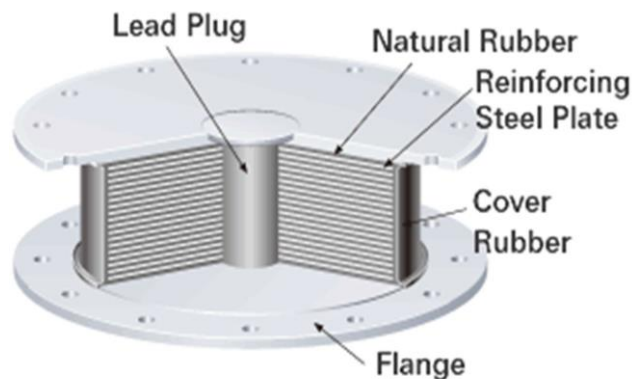


Fig. 2: Lead Rubber Bearing

Friction Pendulum Bearing Approach

The friction pendulum system (FPS) is a generally utilized bearing dependent on the rule of sliding framework and with a pendulum type isolator to give a damping capacity utilizing erosion. The FPS isolator has an articulated slider moving on a spherical friction surface coated with a self-lubricating composite material. The FPS isolator is economical compared to elastomeric bearings. The schematic diagram of FPS isolator is shown in Fig. 3.

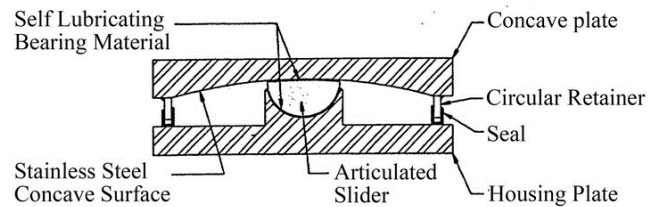


Fig. 3: Friction Pendulum Bearing

1.3 Problem Statement

In Traditional approach Past earthquakes has demonstrated that many buildings and typical methods of construction are inadequate with regards to essential protection from seismic tremor powers. This opposition can be accomplished by straightforward, economical standards of building development. Adherence to these guidelines won't forestall all harm in moderate or huge seismic tremors, yet dangerous breakdown can be forestalled, and limit harm to repairable extents.

II. LITERATURE REVIEW

In this paper, main objective is to check the performance of plan irregularity for base isolation system, to check effectiveness of base isolation system for plan irregularity specially for diaphragm irregularity which is one of the types of plan irregularity and to find story displacement, story drift and base shear And The seismic response of the (RC) building, base isolated by lead rubber bearings (LRBs) is compared with the seismic response of the same structure which does not have base isolation system, analytical study is performed to find response of an irregular structure located in severe earthquake zone. Analysis is carried out by taking 5 story building by static and dynamic methods using ETABS-v16.0.0 software and IS code 1893-2002 (Part 1) as shown in Fig. 4 [1].

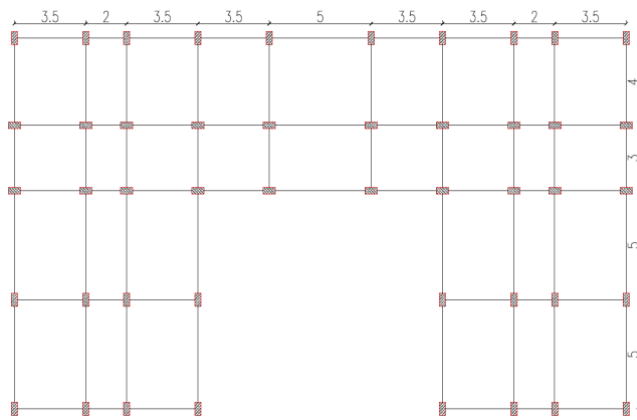


Fig.4: Plan of c-shaped G+5 storey building

Right now, the reaction of Base detached structure and fixed base structure are assessed for elevated structure having inconsistency in plan at Story level. Reaction range investigation and time history examination completed regarding Story Displacement, Base shear, Time period and Story float utilizing ETABS programming [2]. The investigation is performed to look at the adequacy of base disconnection in customary and sporadic multi-celebrated RC outline building. For this examination, 15 celebrated R.C outline building has been considered and Time History investigation is done utilizing ETABS programming adaptation 2013. The outcomes acquired from the investigation are analysed regarding timeframe, base shear, story removal and story speeding up [3]. In this research, asymmetric structures with plan irregularity are compared. For creating the asymmetry in the structures, eccentricity from 0% to 30% is provided in centre of mass of the structure. To assess the effect of LRB isolators on the response of structures, for the present study 4 types of structures having same outer perimeter area are considered. Both fixed base and base isolated models are created and analyzed in ETABS-2016 software. Comparison based on eccentricity is also carried out by varying the height of the structure from low-rise to high rise building [4].

Throughout this paper, various structural aspects of building isolated with friction pendulum bearing system such as building deflection, inter story drift as shown in fig. 5 and overturning moment were studied. The study was done using the software, E-tabs 2015, by conducting nonlinear time history analysis on the structure. A comparative study was also conducted based on these aspects for single, double and triple concave friction pendulum bearing system and it was found that triple pendulum bearing isolator was superior among the three [5].

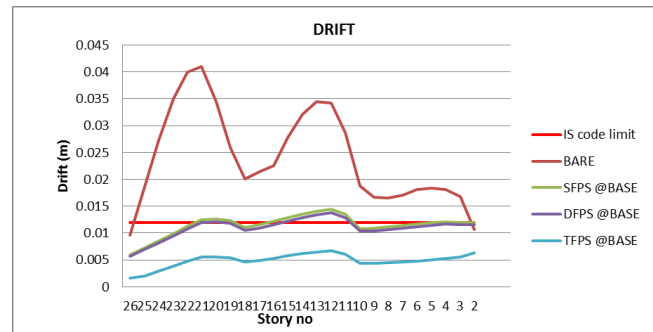


Fig. 5: Plot of story drift for different isolators

The examination is performed for correlation the viability of fixed base and base detached multistoried RC outline building. For the examination, two structures are viewed as the principal structure G+5 story building and second structure G+17 story building which is planned and dissected. The lead elastic bearing (LRB) and rubbing pendulum framework is structured according to UBC97 and ASCE07 code and the equivalent was utilized for the investigation of base segregation framework. The outcomes got from the examination were timespan and base shear. Timeframe for the base detached structure higher than that of fixed based structure. Base shear is fundamentally decreased toward every path (X and Y bearing) when contrasted with fixed base structure by utilizing the isolators [6].

This paper presents an investigation on the seismic reaction of different arrangement unpredictable structures under various base detachment procedures via doing a reaction range examination on the structure models utilizing ETABS 2015. This paper considers different parameters, for example, all out base shear power, story increasing speed, dislodging and timespan of a structure regarding the fixed base and disengaged base (grinding pendulum and lead elastic bearing isolator). The investigation likewise looks at the exhibition of three sporadic structures with L-shape, T-shape and in addition to shape in plan with same territory. The investigation presumed that the fuse of isolator system decreased the story float, speeding up and base shear esteems. The investigation demonstrated that the in addition to molded structure offers better execution when contrasted with different models [7]. This paper manages another kind of base confinement application. The work incorporates structure of G+5 and G+17-story strengthened solid structure as per IS 1893:2002 arrangements; one with fixed base and other is base disengaged. By examining the fixed base structures, we get greatest responses under every section. For these most extreme qualities Lead Rubber Bearings (LRBs) were planned physically so as to separate the superstructure from substructure. Time History Analysis (THA) is completed by taking El-Centro quake ground movement records [8].

Right now, a concise presentation, the reaction range to the seismic tremor safe structure is depicted. As a numerical model, a fourteen story structure broke down with three distinctive seismic insurance options as fixed base, elastic bearing, contact pendulum bearing. In deciding the particulars of isolators, such gadget highlights are mulled over, which would move least consequences for to the structure as tried by various trials based on the criteria, including base and story shear powers, story and relative story floats while the isolators would experience sensible relocations. By and by, such examination couldn't give full streamlining; the principle objective here is to make a correlation between the seismic seclusion and fixed based structure, instead of looking at the seismic segregation choices inside themselves. In the examination, absolute base shear powers, story shear powers and relative story floats are thought about and results are talked about [9].

The paper deals with the comparison of different types of bearing and their performance, the mathematical equation have tried to analyzed the multi storied building with different cases [10].

In this work, considered G+15 as shown in fig. 6 and 7 storey regular and irregular RC framed building have been analyzed with and without base isolator under seismic zone V with medium soil. The considered base isolation systems are High damping rubber bearing (HDRB), lead Rubber bearing (LRB) and friction pendulum bearing system (FPS) have been used at the foundation level and analysis are carried out using response spectrum method in ETABS 2015 Software response of structure such as time period, storey displacement, storey shear, storey acceleration and storey drift are studied and comparison is made between seismic response of Symmetrical and asymmetrical building with and without base isolators. From this study it can be concluded that it is better to provide isolation systems in seismic proven areas rather than providing fixed base and among three isolators used here FPS performs better than HDRB and LRB base isolators [11].

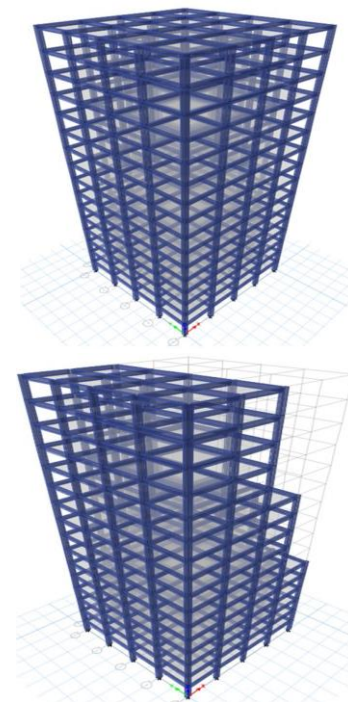


Fig. 6: 3D model of G+15

Fig. 7: 3D model of
Regular model
G+15 Irregular mode

The study is performed to compare the effectiveness of base Isolation in plan unbalanced and vertical multi-storied RC frame building. For this study, no of Storied R.C frame building is well thought-out and time times gone by analysis is conceded out using ETABS Software. The lead rubber bearing is designed as per code and the same was used for psychotherapy of base isolation system. The results obtained from the analysis were time period, base reaction, Story drift and story acceleration. Time period for the base isolated structures are elevated than that of the permanent base structure. Due to the presence of base isolation, base shear is significantly Reduced in each direction (x and y direction) as compared to fixed base building. It has been found that when compared to plan base isolated building gives better performance in high Seismic prone area by using isolators at the base of the building [12].

In this study, a comparison is made of the seismic response of a G+7 and G+14 story base-isolated building by idealizing the superstructure as rigid and flexible. In this work the Lead Rubber Bearing (LRB) isolation system is considered. Two different heights of buildings low and medium rise in zone V is considered. For such analysis ETAB software was used. 3 bay G+7 and G+14 story structure was analyzed for dynamic earthquake using response spectrum method. This paper intends to demonstrate how an isolation system can be efficient, evaluating its effectiveness for the

building in terms of story acceleration, base shear, story drift and story displacement reductions [13].

In this paper study of base isolation, irregular shaped six models have been analysed without base isolation, with rubber isolation and friction isolation using Etabs software. A building was analysed using the equivalent lateral force method and response spectrum analysis as fixed base (FB) and as isolated base (IB), So in this work the performance of RC building in dynamic are studied with base isolation and the results are compared with the results obtained for building without base isolation. A seismic assessment of the structure, disconnected with the LRB and FPS, is performed utilizing a nonlinear three-dimensional investigative model. The parametric examination is focused on base shear and relocations of separated models having geometric inconsistencies in vertical and plan [14].

This paper gives thought regarding base separation framework which can be utilized in multi-story working to lessen seismic reaction of the structure. This paper speaks to the introduce investigation of dynamic parameter like compelling damping for four quake time history. Right now ideal powerful damping has been discovered under the impact of Loma Prieta tremor time history. The parametric study has been conducted to evaluate the effect on maximum displacement, maximum acceleration, maximum base shear in bare frame and frame with isolator [15].

The paper discusses about behaviour of isolators in symmetric buildings with underground stories. It is only focuses on comparison made about lead rubber bearing isolators and friction pendulum system placed at basement of buildings and linearity behaviour of isolators in symmetric building with basement stories [16].

In the present study G+15 storey building is considered and linear time history has been applied. The finite element analysis has been done using ETABS 2015. Comparison of a regular building with a fix base with different base isolators that is Lead Rubber Bearing (LRB) and Friction Pendulum Bearing (FPB) has been done. Various parameters such as storey displacement and story drift have been calculated and compared [17].

This paper investigated model used for the study is assumed to be a 15 storey public building in an area classified under the earthquake zone V. The Response Spectrum method is used for evaluating the performance of fixed base and base isolated building models. The response spectrum function is taken from IS 1893:2002 with 5% in structure damping.

comparison of different bearing types like fixed bearing Lead rubber bearing Friction pendulum bearing is done [18].

In this dissertation design of lead rubber bearing is to set the target period (Assume 2 seconds) and the effective damping β is assumed to be 5% for reinforced concrete structure according to IS 1893:2002 Clause No. 7.8.2.1. Similarly decide the minimum rubber bearing diameter depending on vertical reaction. Analyses of G+5 building using Equivalent static load method, Time history method and Response spectrum method. For isolation systems Stiffness is the crucial parameter. This iterative procedure is preceded by giving stiffness as input parameter by assuming time period and the model with isolated base is examined accordingly [19].

The aim of this research is to study the seismic behavior of different structures under fixed condition and base isolated condition. In present study Modeling and analysis of G+5 storey RC building is done in ETABS software for two cases. The 01st one is fixed base and the 02nd one is base isolated. The Lead rubber bearing (LRB) is designed as per UBC 97 code and the same was used for analysis of base isolation system. Lead rubber isolator are provided to both the structures and then analysis are carried out for both fixed base and base isolated buildings under zone II and soil type II i.e. medium soil (according to IS 1893(part 1):2002). The results obtained from analysis were Storey displacement. Storey shear, storey acceleration, and Inter storey drift. Due to the presence of isolators the inter storey drift, storey accelerations and storey shear is greatly reduced and storey displacement as shown in Fig.8 is increased in both X and Y directions compared to fixed base structures [20].

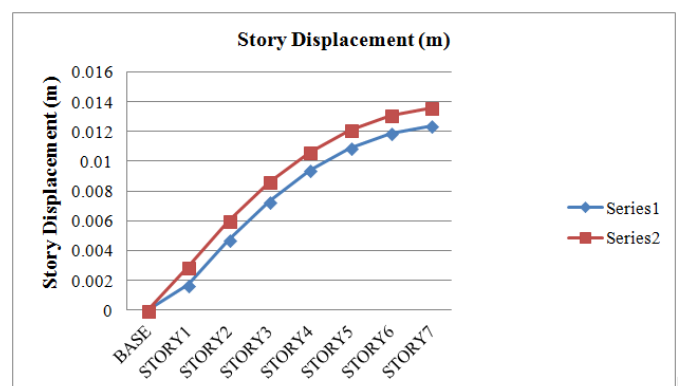


Fig.8: Story Displacement for Base and Isolation Support

Right now dimensional nonlinear time history analysis is performed on r/c working by the utilization of computer program SAP 2000 v12.0.0. The dynamic investigation of the structure has been done and the presentation of the structure with and without isolator is

contemplated. The principle objective here is to make seismic reaction control by giving Isolators and looking at between the fixed based and confined base structure. Elastic bearing and Friction pendulum bearing are utilized [21].

Right now, appropriateness of sort of elastomeric base isolators and their viability to diminish interstorey floats and increasing speeds of the structures is examined. The impact of shear dividers on base secluded structures is additionally considered. A short thought regarding base detachment and its various kinds is required already. This is an audit paper arranged as a piece of the proposal work [22].

Point of this task is to shield the structure from seismic tremor and spare the life of individual. Presently a days Material of base disconnection is expensive and hard to execute. Steel or fiber support inside the elastomer isolators gives high vertical solidness, where elastic sections between fortification layers give low flat firmness to the seismic base disconnection [23].

The exploration introduced in this examines the capacity of a versatile seismic seclusion framework to ensure structures exposed to an assortment of quake ground movements. Seismic seclusion empowers decrease in tremor powers by extending time of vibration of the structure. A base disengagement framework must fulfill four essential criteria of viability, specifically, speeding up reaction, shear and toppling minutes are decreased by a factor of four to eight for structures mounted on isolators. A specific GAPEC kind of confinement framework received in New Bhuj Hospital that crumbled during Bhuj 2001 quake and finished with seismic tremor building New Zealand Technology is considered .The 300 bed Bhuj Hospital that asserted 176 lives when it fallen during the significant January 2001 Gujarat Earthquake is examined. This was the first new structure in Quite a while to be fitted with tremor – safe NZ created base segregation innovation. In the end, 280 lead elastic direction were introduced in the structure [24].

Damper. Right now there is insight regarding each of the five seclusion frameworks and examination between Friction Pendulum and Laminated Rubber Bearing for a 10 story building and decision about which is the best disengagement framework for the two. Relative investigation of straight and non-direct base isolators has likewise been completed. Straight and non-direct time history investigation has been finished utilizing El Centro tremor [25].

The essential point of this paper is to investigation of various sorts of base isolators like covered elastic bearing, lead elastic bearing and erosion pendulum bearing from

surveys of different research papers and how to diminish tremor consequences for structures by utilizing various systems [26].

The current paper centers around the exhibition assessment of a couple of uninvolved control frameworks, for example, base confinement frameworks and tuned mass dampers in the vibration control of a direct multi celebrated structure under consonant and seismic tremor base movements. Base isolators, for example, Lead Rubber Bearing (LRB) framework and Friction Pendulum System (FPS); and, a tuned mass damper (TMD) are intended for a ten celebrated strengthened solid structure. The structure is displayed as a 10 degrees of opportunity shear building model and Bouc Wen model is utilized to depict the hysteretic conduct of base isolators. The presentation of LRB framework, FPS and TMD are assessed numerically and looked at. The recurrence reaction qualities of the frameworks are additionally considered [27].

This paper connected to A trial concentrate on the dynamic qualities of CIS, including flat firmness, damping and their variety with recurrence of parallel stacking, vertical weight and shear strain, is directed. Trial examination demonstrates that CIS have the upsides of sliding elastic bearing and regular elastic bearing. At that point a count model of CIS is gotten from the examination dependent on the investigation. Moreover, another isolator of CIS is intended for a handy structure lessening seismic reaction. Nonlinear seismic reaction investigation of the structure with CIS is performed. The examination investigation shows that CIS can fundamentally moderate the seismic reaction, base shear, yet additionally story floats of the structure with worthy relocations of the isolator [28].

This paper examines theseismic reaction of base-disconnected structures with LRB and FPS isolators under close to blame ground movements. A seismic assessment of the structure, secluded with the LRB and FPS, is performed utilizing a nonlinear three-dimensional expository model. The parametric examination is focused on base shear, increasing velocities and relocations of disconnected models. Enormous dislodging and speed beats in records of close to blame ground movements can fundamentally change the consequences of seismic reaction of base-secluded structures [29].

This paper provides details regarding a Network for Earthquake Engineering Simulation (NEES)/E-Defense cooperative test ing program on base-confined structures. A full-scale, five-story, in pairs sound, steel minute casing building was exposed to various bidirectional and bidirectional-in addition to vertical ground movements

utilizing the EDefense shake table. The structure was tried under three unique designs: 1) base disconnected with triple friction pendulum course (TPB), 2) base segregated with a blend of lead-elastic heading (LRB) and cross-straight direction (CLB), and 3) fixed-base. This paper presents the aftereffects of shake table examinations on full-scale base-detached structure and shows the viability of ongoing base-segregation methods for visit, close blame and long span subduction quakes. In view of test results, it was discovered that TPB framework gave more prominent weakening of floor increasing velocities for the ground movements with PGA bigger than 10 m/s² while LRB-CLB framework gave more noteworthy constriction of floor increasing velocities for ground movements with PGA littler than 5 m/s² [30].

Right now Base Isolation frameworks are explored from the verifiable confirmations up to now. The work introduced in this depends on near point of view of various strategies proposed to date dependent on their similarity, effectiveness, advantages and shortcomings of every framework that are thought and broke down. At long last a five-story working as a contextual analysis has been thought about through reproduced investigation for both, with and without base disengagement frameworks. Numerical investigations are applied so as to watch dynamic conduct of such structures under seismic burdens. Brief survey of the economy and commonsense adequacy of base-segregation frameworks is accounted for culmination [31].

The current examination points is to make a detail of high elastic bearing and lead plug elastic bearing framework for a G + 4, multi celebrated structure considering the impact of seismic tremor regarding IS : 1893 (Part I) : 2002, in zone V and IV districts, in order to cause working to seclude from earth to disseminate quake impact. The goal of the examination is to utilize most recent American standard code ASCE – 07, for structure of high elastic bearing framework and lead plug elastic bearing framework, for G + 4 multi celebrated structure and to detail the bearing framework subtleties. The bearing frameworks considered are likewise watched for change in their structure detail for zone V and zone IV according to Seems to be: 1893(Part I): 2002. The utilization of ASCE code was made with regards to the announcement made in introduction of IS: 1893(Part I): 2002, which gives us opportunity to utilize universal codes of norms for defending the structures in Indian country. Lead plug bearing framework, high elastic bearing framework are two frameworks broadly utilized for disengagement of structures and henceforth are considered for the plan of seismic seclusion of thought about structure. This examination objective is to clear a path for use of worldwide benchmarks in Indian states of structure [32].

This paper condenses current practices, depicts generally utilized seismic disengagement equipment, annals the history and advancement of present day seismic seclusion through shake table testing of separated structures, and audits past endeavors to accomplish three-dimensional seismic detachment. The audit of ebb and flow rehearses and past research are integrated with ongoing improvements from full-scale shake table testing to feature territories where research is expected to accomplish full seismic harm security of structures. The accentuation of this paper is on the use of aloof seismic separation for structures principally as rehearsed in the United States, however frameworks utilized in different nations will be talked about [33].

Right now, unpredictable RC working of G+10 stories is demonstrated and broke down with and without base isolators utilizing SAP 2000 programming of rendition 14.2.4. The exploratory work arranged right now of completing the examination in static manner (Equivalent Static Analysis) and dynamic way (Time History Analysis) taking the parameters of El-Centro seismic tremor. It is seen that by giving Lead Rubber Bearing as base isolator the structure is more secure than Friction Pendulum Bearing detached structure as per all the parameters [34].

The point of this examination is the utilization of High thickness elastic bearing (HDRB) and rubbing pendulum framework (FPS) as a disengagement gadget and afterward to look at different parameters between fixed base condition and base segregated condition by utilizing SAP2000v14 programming. Right now (G+12) story clinic building is utilized as a test model. Nonlinear time history examination is completed for both fixed base and base disconnected structure. The result got shows the decrease in base shear in both heading and increment in the relocation and timeframe for the base isol

In this section total 3 analysis was done for 6-storey structure using BI-HDRB and BI-FPS isolators by El-Centro earthquake ground motion data. All the analysis was done by nonlinear time history analysis. Type of analysis for all the structures is modal nonlinear time history analysis considering international El-Centro ground motion data. International ground motion data for El-centro is the 1940 North South component also known as pekold version having 1559 acceleration data points at 0.02 sec. The PGA value for El-centro earthquake is 0.33g. In this section comparative results are presented fixed base model what we call it FB, then for BI-HDRB and at last BI-FPS. To access the performance of low-rise reinforced concrete structure with different arrangement of base isolators at the base of structure such as Fixed Based, High Density Rubber Bearings (HDRB) and Friction

Pendulum System (FPS) type. For this study, structure is analyzed with the help of SAP2000v14 software. For this the modeled as shown in Fig. 9 fixed base structure (FB) and the isolation devices designed for it using the UBC-97 (UBC, 1997) [10] and IBC2000 requirements [36].

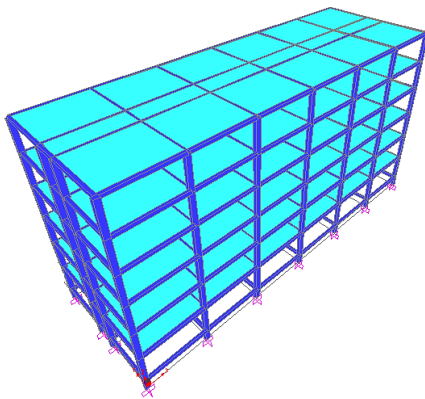


Fig. 9: Fixed base 6-storey structure

In this paper study has been concentrated on an eight storied (G+8) buildings. The fixed base and Base isolated building performance point is calculated by using SAP-2000 software and story drift is for EQ-X and EQ-Y direction is calculated and hinges also form to the structure. The seismic zone is IV. Grade of concrete is M20 and for steel Fe415. The figures of different factors have been assumed as per IS: 1893(Part-1) -2002. The design of members has been carried out as per IS: 456-2000 the beam and column has been design by IS: 456-2000(5) [37].

In this paper (G+15) RCC building is considered for the case study. Its modeled in SAP2000 software and analyzed for fixed base, bracing and Isolator. The non-linear time intervals analysis is carried out by considering El-Centro time history ground acceleration data. Theoretical comparison is then worked out between the fixed base and the base isolated structure and the parameters such as base shear, mode period, storey displacement, storey drift and storey acceleration. The Fig. 10 shows the maximum base shear in X directions [38].

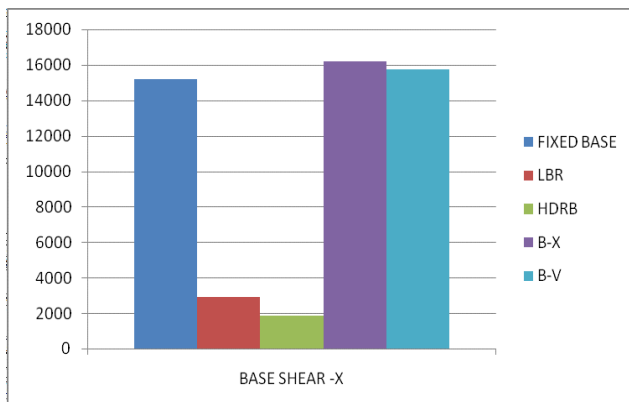


Fig.10: Base shear X

The aim of this paper is to reduce the base shear, story drifts and story acceleration due to earthquake ground excitation, applied to the superstructure of the building by installing base disengagement gadgets at the establishment level and afterward to look at the changed exhibitions between the fixed base condition and base-segregated state of even structure. The high damping elastic disconnection framework has been utilized at the establishment level. Non direct time history investigation has been performed on El-Centro tremor. Looking at the aftereffects of the base - disconnected condition with those got from the fixed-base condition has demonstrated that the base confinement framework lessens the base shear power, story floats and story speeding up, additionally expanding the story removal and timespan [39].

In the studied base isolation and the braced building is compared and analyzed by using SAP2000 software. The analysis is done by using modal Linear time history analysis of (G+6) RCC building. Time history analysis is performed on earthquake EL Centro 1940. The analysis on structure has been performed and response of building with base isolator and bracing is studied. The main objectives were to study the response of earthquake by providing base isolator and Cross Bracing building. The lead rubber bearing is used as isolator and steel section is used as bracing. the result from time history analysis like time period, acceleration joint displacement of the frame structure were found out and studied.

Cross bracing is used in a frame structure for reinforcing the frame in which the diagonal member meets at a common point. By use of cross bracing its increase the chance of a building to withstand seismic activity. Cross bracing is most commonly used they are in X-shape supported by two diagonal members, this supported member are in compression and tension forces. Depending on weather forces is a lateral force or the wind the member of the brace are in tension and compression. It helps make buildings more rigid so that building withstands the earthquake forces, Fig. 11 shows the construction details of cross bracing [40].

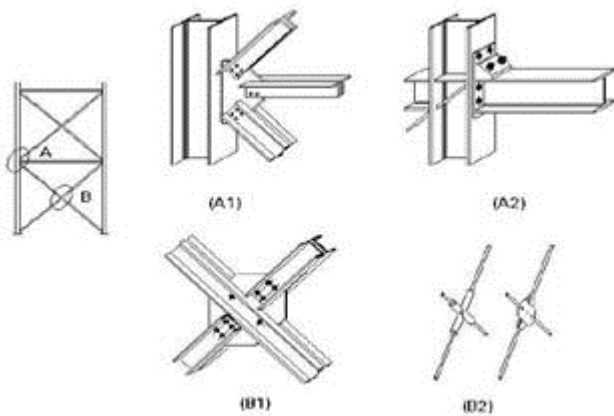


Fig.11: construction details of cross bracing

This article aims to study the response of G+3, G+10 and G+20 building models with different types of isolators (Lead rubber bearing and Friction Pendulum bearing) in respect of base shear, inter-storey drift, inter-storey displacements, frequency and time period when analyzed by different philosophies of analysis procedures (Equivalent Static Force Procedure [EQS], Response Spectrum Analysis [RS] and Time History Analysis [TH]). The results of the parametric study were compiled and discussed in an effort to draw conclusions so as to be able to suggest the type of isolation to be adopted, Fig. 12 shows the time history of may 18, 1940 El Centro Earthquake [41].

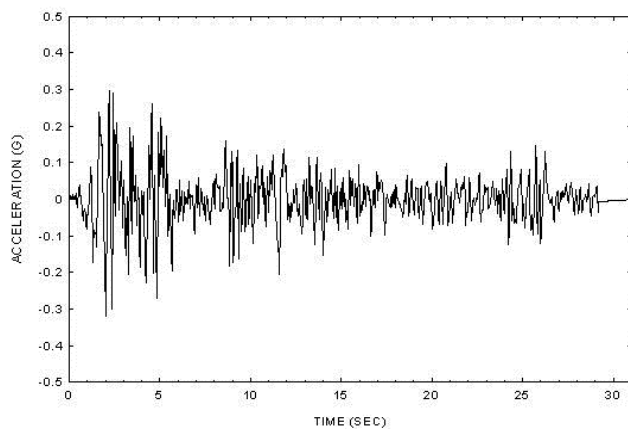


Fig.12: Time History of May 18, 1940 El Centro Earthquake

The aim of this paper is the use of lead rubber bearing (LRB) as an isolation device and then to compare various parameters between fixed base condition and isolated base condition. In this study, comparative advantages for using lead rubber bearing (LRB) isolation systems are mainly investigated by performing nonlinear dynamic time history analyses for design basic earthquake (DBE) seismic demand level. The comparison process has been carried out on structural performance of the structure with storey displacement, storey acceleration, and storey drift ratio. In

performance assessment phase, probable damage cost, repair time and rate of injuries are computed using fragility curves and FEMA P-58 methodology in Performance Assessment Calculation Tool (PACT). The lead rubber bearing system (Myanmar rubber, RSS-3) was developed to reduce damage cost, repair time and rate of injuries of the buildings subject to earthquake [42].

In this paper the isolation systems considered for this study are Laminated Rubber bearing (LRB), Lead Rubber Bearing (N-Z bearing) and Friction Pendulum System (FPS). The response of fixed base building and of base isolated building is compared in terms of maximum top floor acceleration, inter-storey drift, maximum floor displacements and base shear. For parametric study important isolation system parameters considered are: (i) isolation time period, isolator damping for LRB; (ii) isolator yield strength, isolation time period, isolator damping for N-Z bearing and (iii) isolation time period, friction coefficient for FPS. It is found that base isolation technique is very effective in reducing seismic response of structure and isolation system parameters significantly influence the earthquake response of a base isolated structure [43].

In this paper Base-separation was more current plan idea to viably control the seismic reaction of common structures by lessening characteristic recurrence and increment damping, utilizing regularly heading made of elastic. In spite of the fact that it had applied to numerous • raised roadway spans, base detached scaffolds had not been presented to deplorable tremors. In this paper, seismic record in 1995 Kobe tremor acquired at an observed base-confined extension was broke down to examine its real seismic conduct and execution of the. The seismic exhibition base-separated extension was confirmed by quantitatively indicating the vulnerabilities related with both estimation and demonstrating [44].

In this paper, advanced nonlinear assessment in light rail travel (LRT) structures had gotten a handle on to survey the impact of seismic separation gadgets for lessening seismic interest. The evaluation utilized the utilization of two kinds of monetarily accessible heading, to be unequivocal lead flexible bearing (LRB) and breaking down pendulum structure (FPS). Six LRT structures, expected to be worked in Surabaya, were demonstrated utilizing PC helped programming SAP2000, where everything of the three structures included three kinds of LRB and FPS set onto the dock top to empower the tons upper-fundamental to part. Nonlinear static sucker and dynamic time history assessment with seven improved ground advancement information was performed to extend improved bits of knowledge on the lead reaction of LRT structures, permitting one to completely value

the extraordinariness of seismic detainments for confirming the structure against seismic activities. It's indicated that the 2 devices add up of the way to keep seismic forces, achieving facilitating of over the highest base shear occurring at the portion. Additionally, it had been conspicuous that the overall responses of LRB and FPS shows minor blunders, prescribing the 2 contraptions are tradable to be used for LRT-like structures [45].

In this paper, a multi-target progress for the perfect game plan of sliding partition frameworks for covering of seismic reactions of building structures was introduced. Due to the closeness of two or three parameters affecting the presentation of sliding base segregation structures, applying a comprehensive multi target improvement system is unavoidable. From this point forward, during this assessment, the acquired calculation is employed to get ideal estimations of isolator parameters; including coefficient of scouring was mass of base vessel and therefore the damping degree of the re-establishing power gadget. The re-establishing contraption, which was made out of a straight spring and an immediate goeey damper, was connected to the bottom burst so on limit the during-occasion and after-occasion sliding dislodging of the bottom pontoon. The concurrent minimization of the structure's top story evacuating and its accelerating, and additionally the bottom canal boat's development, was considered as far as possible. To satisfy as far as possible, a sensible and elitist Non-controlled Sorting Genetic Algorithm (NSGA-II) is employed to locate tons of Pareto-ideal approaches. The isolated structure was appeared as a shear-type structure having one sidelong level of chance at every story level. A ten-story building was utilized for the numerical evaluation and a get-together of seven seismic tremor records was considered for the assessment. The outcomes display that by applying the last course of action parameters obtained from the perfect qualities found by the NSGA-II approach appearing differently in reference to every individual record, the sliding isolator framework adequately covers the key seismic reactions. In like way, it's discovered that the re-establishing gadget with a perfect goeey damper may scarcely decrease the presentation of the separation framework, yet is unequivocally persuading in controlling the simplest base pontoon ejection and therefore the remaining base narrow boat dislodging [46].

The paper manages the seismic retrofit of a substitute structure having a spot with the Hospital Center of Avellino (Italy). From the earliest starting point, the paper shows the starter appraisals, the in situ estimations and research office tests, and the seismic assessment of the energy fixed-base structures. Having thought about various procedures, base withdrawal end up being the furthermore fitting, in like way

for the trustworthiness offered by the geometry of the structure to effectively make a parcel interface at the ground level. The paper displays the game plan experience, the improvement procedure, and the subtleties of the disconnection intercession. Some particular issues of base division for seismic retrofitting of different structure structures were had any kind of effect. At last, the seismic evaluation of the base-segregated structure was done. The seismic reaction was assessed through nonlinear time-history assessment, utilizing the striking Bouc-Wen model as the constitutive law of the partition course. For solid weighty assessments, a suite of typical accelerograms incredible with quickening spectra of Italian Code was first picked and sometime later applied along both even headings. The outcomes were at long last used to address a piece of the basic issues of the seismic reaction of the base-disengaged distinctive structure: unplanned torsional impacts and potential poundings during strong tremors [47].

This paper explains, Seismic disconnection was useful system for shielding success related atomic structures from the impacts of moderate to certified shiver shaking. In any case, seismic isolation had been passed on in atomic structures in France and South Africa; it has not seen wide use due to restricted new structure atomic improvement in the previous 30 years and a nonappearance of rules, codes and measures for the assessment, plan and headway of detachment frameworks unequivocal to atomic structures. The financing by the United States Nuclear Regulatory Commission of an examination set out to the Lawrence Berkeley National Laboratory and MCEER/University at Buffalo upheld the synthesis of a bound to-be-passed on NUREG on seismic division. Supporting of MCEER by the National Science Foundation impelled get some information about things that give the specific motivation to another bit in ASCE Standard 4 on the seismic regulation of success related atomic work environments. The introduction needs perceived in the NUREG and ASCE 4 for seismic detachment frameworks, and superstructures and substructures are depicted in the paper. Vivacious numerical models fit for getting isolator practices under crazy loadings, which have been confirmed and embraced after ASME appears, and acknowledged in the open source code Open Sees, are presented [48].

Probably the hugest improvement in fundamental planning within the past 20 years has unmistakably been the advancement of execution based arrangement as techniques for selecting, proportioning, and building assistant structures to limit seismic excitations. This system was a perfect framework for structure in sight of its versatility concerning the choice of execution objectives, the depiction and propagation of both intrigue and block, and therefore the bigger treatment of defenselessness. A tremendous nature

of the way of thinking is that introduction targets could also be portrayed almost like assistant execution, basic limit, budgetary examinations, and biological sensibility. This structure has the engaging component of giving an estimation of execution which will be completed by a good arrangement of system accomplices, including modelers, building owners, transitory laborers, assurance providers, capital endeavor proprietors, and open specialists. As assistant planners train their consideration on broadly described responses for the challenges displayed by maintaining and improving human headway, execution based structure will dynamically accept a central activity. This innovative method to manage arrangement demands the utilization of imaginative essential systems to realize the complex and potentially multi-target execution destinations envisioned by the varied accomplices. Given the weakness that's unavoidably present in any seismic tremor safe arrangement structure, innovative systems must not only be fit obvious response to deterministic data yet even be sufficiently solid to reply reliably to a good extent of potential data. Seismic isolation structures are undeniably fitting for execution inside an introduction based framework considering the way that: (an) energetic depictions of their direct are often made through experimentation, (b) the difference in watched lead from foreseen that was consistently low relative should normal helper parts, and (c) it'll generally be trying or maybe hard to realize an improved show objective without the utilization of seismic separation. Appeared differently in reference to standard helper structure for seismic restriction, disengagement gave an exceptional and powerful techniques for simultaneously reducing shake hurt in both distorting fragile and speeding up unstable parts. Execution based seismic arrangement of structures is at the present encountering imperative improvement thanks to results experienced in progressing shakes. Not simply has there been significant loss of human life in light of injury achieved by genuine seismic tremors, the cash related cost happening thanks to coordinate mishaps (fix of multinational, substitution of hurt substance) and winding setbacks (business aggravations, relocation costs, generation organize impedance) has moreover been imperative [49].

During this paper, the seismic responses of base-isolates sweeping and thin barrel molded liquid accumulating ground tanks were inspected. Three kinds of disconnection systems are considered. The seismic responses are differentiated and therefore the watching responses of non-bound tanks [50].

III. SUMMARY

Some of the paper studies about the analysis of different types of buildings with different Isolators such as Lead rubber bearing, Laminated rubber bearing, Friction pendulum bearing for regular and irregular buildings having a different dimensions. From the different papers, it is observed that the three different buildings (plus, T-shaped and L-shaped), the performance of the plus shaped building is found to be better which may be attributes to its symmetry in plan. It is observed that the lead rubber bearing isolator offers better performance when compared to the FPS isolator. The segregated models had a more noteworthy estimation of float at its base rather than the uncovered casing model. Nonetheless, the worth diminished to a lesser incentive than in the exposed casing model as the story stature expanded. Along these lines base seclusion system is powerful in lessening the float estimation of the structures. The expansion of the isolators to the structure expanded the timeframe of vibration which might be because of the adaptability of the isolators. In many papers The comparison of different parameters like time period, Storey displacement, storey acceleration, storey shear, and storey drift are carried out and tabulated results obtained from response spectrum analysis in ETABS software. Analysis is done for fixed base, HDRB, LRB and FPS base isolated conditions.

IV. CONCLUSION

In this project an attempt is made to comprehend the adequacy of base disconnecting component for quake. Based on the investigation the accompanying ends are drawn. There is a development in time allotment regard for base kept structure diverged from that of fixed base structure. Both the withdrawal structure grows the time span stood out from fixed base. In any case, FPB separation structure gives extra time span than LRB isolation system. Results likewise shows that the time span in the Composite structure is greatest contrasted with RCC and steel structure in both base disengaged additionally, fixed base structures. There is a tremendous lessening in the base shear for the structure with base disconnection when contrasted with fixed base structures. Both the base disengagement framework gives practically same measure of decrease in the base shear for various structures, for example, RCC, Steel and Composite. More decrease in base shear can be accomplished for steel structure when contrasted with RCC and Composite structure. The uprooting of the secluded structure increments because of an enormous increment in the adaptability of the structure. Out of two base isolation systems, it is found that the displacement in FPB isolation is more compared to that of LRB isolation system. The examination result likewise shows that the most

extreme removal is happened in Composite structure when contrasted with RCC and Steel structure. From the analysis result, it is seen that lone the principal story of the base isolated structure gets more story drift value compared to fixed base structure. But in the remaining stores the drift values decreasing in the base isolated structure and the drift value goes on increasing in the fixed base structure. Based on the results, it was also found that among the two isolators, FPB isolator gives better performance compared to LRB isolator for irregular medium story structures.

REFERENCES

- [1] Atiqullah and Tejas M. Patil; Effectiveness of Base Isolation System with Respect to Plan Irregularity in Multistorey RC Building, ISSN: 2395-1990, vol.4 Issue 4 April 2018, PP: 1376-1383.
- [2] Vasu A. Shah and Harsh C. Bakhaswala; Comparative Study of Base Isolation in Multistoried R.C Irregular Building, ISSN: 2348-4470, Vol.4 Issue 11 November 2017, PP: 354-362
- [3] Omkar Sonawne and Swapnil B. Walzade; Effect of Base Isolation in Multistoried RC Regular and Irregular Building using Time History Analysis, ISSN: 2395-6992, Vol.4 Issue 5 May 2018, PP: 30-37.
- [4] Rasna.P and Shinu Shajee; Study on the Effect of LRB Isolators on Different Asymmetric Plans of RC Structure, ISSN: 2319-6734, Vol.7 Issue 4 Ver II, April 2018, PP: 20-28
- [5] Aarthy S. and Manju P.M; Analysis of friction pendulum bearing isolated structure, ISSN: 2395-0056, Vol.3 Issue 8 August 2016, PP: 317-322
- [6] M. Rajesh Reddy and Dr. N. Srujana; Effect of Base Isolation in Multistoried Reinforced Concrete Building, ISSN: 0976-6316, Vol.8 Issue 3 March 2017, PP: 878-887
- [7] Devi Srinivas and Ancy Mathew; Evaluation of Seismic Performance of Re-Entrant Cornered Buildings with Base Isolators, ISSN: 2349-784X, Vol.3 Issue 3 September 2016, PP:117-122 .
- [8] Bhavana Balachandran and Susan Abraham; Effect of Base Isolation in Multi-Storeyed RC Building, ISSN: 2250-3021, Vol.8 Issue 6 June 2018 Ver II, PP: 84-93
- [9] Shirule Pravin Ashok and Niraj Mehta; Response Spectrum Analysis of Multi Storeyed Base-Isolated Building, ISSN: 2249-6866, Vol.2 Issue 3 September 2012, PP: 66-75.
- [10] K S Sable and J S Khose; Comparison of Different Bearing Types Performance in Multistoried Building, ISSN: 2277-3754, Vol.1 Issue 4 April 2012 PP: 336-341.
- [11] Poornima B S and Dr. B S Jayashankar Babu; Comparative Study on Seismic Response of Regular and Irregular RC Framed Buildings with HDRB, LRB and FPS Base Isolation Systems, ISSN: 2321-9653, Vol.7 Issue VI June 2019, PP:805-813.
- [12] Mr. Mithun Narhare and Dr. Ashok Kasnale; Behaviour of Building under Earthquake with or without Base Isolation by Varying Thickness of LRB, Issn: 2321-0613, Vol.7 Issue 4 2019, PP: 433-438.
- [13] Sushil P. Lipte and Dr. V.R. Rathi; Seismic Response Control of Rc Building By Using Base Isolation System, ISSN: 2249-7455, Vol.8 Issue 9 September 2018, PP: 895-909.
- [14] Sunny Patel and Abbas Jamani; Effect of Base Isolation on Seismic Performance of Rc Irregular Buildings, IJARIE ISSN: 2395-4396, Vol.3 Issue 5 2017, PP: 1870-1878.
- [15] Kishan Bhojani and Vishal B. Patel; Seismic Vibration Control of Building with Lead Rubber Bearing Isolator, Vol.1 Issue 2017, PP: 226-231.
- [16] ASST.PROF. Vedika Shah and ASST.PROF. Mittal Patel; Comparative Study of Lead Rubber Bearing and Friction Pendulum System on Building Structure with Basement Stories, ISSN: 2319-507X, Vol.6 (7) Issue 27 January 2018, PP: 45-51.
- [17] Saurabh Dutt Divakar and Dr. Kailash Narayan Upadhyay; Seismic Behaviour of MultiStorey Building with Different Base Isolators, ISSN: 2456-1290, Vol.3 Issue 5 May 2018, PP: 54-56.
- [18] B.R. Aniruddha and R.J. Fernandes; Performance of Base Isolated Building Structures with Asymmetry in Plan, ISSN: 2278-0181, Vol.4 Issue 9 September 2015, PP: 761-763.
- [19] G. Monica and Dr. B.L. Agarwal; Seismic Analysis of Fixed Based and Base Isolated Structures, ISSN: 2348-7550, Vol.4 Issue 8 August 2016, PP: 277-288.
- [20] K Sumani Priya and Ch Durga Rao; Earth Quake Analysis of Structure by Base Isolation Technique in Etabs, ISSN: 2319-6106, Vol.2 Issue 20 October-December 2017, PP: 89-96.
- [21] Sonali D. Anilduke and Amey Khedikar; Study on Base Isolation System for Seismic Response Control, ISSN: 2278-0181, Vol.4 5 May 2015, PP: 1605-1609.
- [22] N K Fasil and Dr. S R Sreemahadevan Pillai; The State of the Art on Seismic Isolation of Shear Wall Structure using Elastomeric Isolators, ISSN: 2395-0056, Vol.5 Issue 4 April 2018, PP: 1349-1351.
- [23] Mukesh Chauhan and Digant Patel; Study of Scrap Tire Used as Base Isolation Material, ISSN: 2393-8374, Vol.3 Issue 9 2016, PP: 96-101.
- [24] Nirav G. Patel; Study on a Base Isolation System, ISSN: 2348-7968, Vol.1 Issue 8 October 2018, PP: 244-247.
- [25] Parth Shah and Yash Rane; Comparison Between Friction Pendulum System and Laminated Rubber Bearing

- Isolation System, ISSN: 2395-0056, Vol.4 2 February 2017, PP: 81-85.
- [26] Yogesh N. Sonawane and Chetan J. Chitte; Study Between Laminated Rubber Bearings and Friction Pendulum Bearing of Base Isolation System: A Review, ISSN: 2321-9653, Vol.6 Issue 3 March 2018, PP: 2824-2828.
- [27] Julee S and Sajeeb R; Performance of Base Isolators and Tuned Mass Dampers in Vibration Control of a Multistoried Building, ISSN: 2278-1684, Vol.2 Issue 6 September-October 2012, PP: 1-7.
- [28] Weixing SHI and Huangsheng SUN; A Study on Combined Isolation System, Issue 1-6 August 2004, paper No. 2232.
- [29] M.K. Sharbatdar and S.R. Hoseini Vaez; Seismic Response of Base-Isolated Structures with LRB and FPS under near Fault Ground Motions, www.sciencedirect.com.
- [30] Tomohiro SASAKI and Eiji SATO and Keri L. RYAN; NEES/E-Defense Base-Isolation Tests: Effectiveness of Friction Pendulum and Lead-Rubber Bearings Systems.
- [31] Hossein Monfared and Ayoub Shirvani; An investigation into the seismic base isolation from practical perspective, ISSN: 0976-4399, Vol.3 Issue March 2013, PP: 451-463.
- [32] T. Nagajyoti and Dr. Vaishali G. Ghorpade; Design of Lead Rubber Bearing System and High Damping Rubber Bearing System for Isolated Structure for Long Time Periods for a Five Storey R.C. Building, ISSN: 2277-9655, Issue August 2015, PP: 379-387.
- [33] Gordon P. Warn and Keri L. Ryan; A Review of Seismic Isolation for Buildings: Historical Development and Research Needs, ISSN: 2075-5309, Issue 3 August 2012.
- [34] Zaheer Ul Hasan Samdani and Ravichandra.R; Comparative Study on Performance of Multi-Storey Structure Rubber Bearing and Friction Pendulum Base Isolation Systems, ISSN: 2394-2975, Vol.2 Issue 2 April-June 2015, PP: 150-154.
- [35] Ashish R. Akhare and Tejas R. Wankhade; Seismic Performance of RC Structure Using Different Base Isolator, ISSN: 2277-9655, Issue May 2014, PP: 724-729.
- [36] T.R. Wankhade and A.R. Wankhade; Effect of Combined Isolation System on Low-Rise RC Structure, ISSN: 2347-1697, Vol.3 Issue 2 October 2015, PP: 538-550.
- [37] T. Subramani and J. Jothi; Earthquake Analysis of Structure by Base Isolation Technique in SAP, ISSN: 2248-9622, Vol.4, Issue 6 (Ver 5) PP: 296-305.
- [38] Dr. R. S. Talikoti and Mr. Vinod R. Thorat; Base Isolation In Seismic Structural Design, ISSN: 2278-0181, Vol.3 Issue 7 July 2014, PP: 863-868.
- [39] S.D. Gowardhan and Manoj U. Deosarkar; Protection of the Buildings from the Earthquake Risk Using High Damping Rubber Bearing, ISSN: 2349-8404, Vol.2 Issue April-June 2015, PP: 27-31.
- [40] Ajay. G. Singh and Ajay K. Lohar; Analytical Behaviour of Multistoried Building with Base Isolation and Cross Bracing Subjected to Earthquake Loading, Vol.7 Issue No.4, PP: 11100-11103.
- [41] Rashmi Guptha and Dr. G. S. Manjunatha; Parametric Study of the Effect of Base Isolation on Performance of Structures, ISSN: 2394-9333, Vol.3 (4) Issue July-August 2016, PP: 7-12.
- [42] Nwe Nwe Win, and Zaw Min Htun; Comparative Study on Performance Assessment of Steel Structure with Lead Rubber Bearing System (Myanmar Rubber) and Fixed Base, ISSN: 2349-1442, Vol.4 Issue January 2017, PP: 18-24.
- [43] Sunita Tolani and Dr. Ajay Sharma; Effectiveness of Base Isolation Technique and Influence of Isolator Characteristics on Response of a Base Isolated Building, ISSN: 2320-0847, Vol.5 Issue May 2016, PP: 198-209.
- [44] Masato Abe “Seismic performance evaluation of base-isolated bridges” IFAC Control in Natural Disasters, Tokyo, Japan, 1998.
- [45] Santi Nuraini “A comparative study of base isolation devices in light rail transit structure featured with lead rubber bearing and friction pendulum system ” MATEC Web of Conferences 195, 02013 (2018) <https://doi.org/10.1051/mateconf/201819502013> ICRMCE 2018.
- [46] N. Fallah “Multi-objective optimal design of sliding base isolation using genetic algorithm” Sharif University of Technology Scientia Iranica Transactions A: Civil Engineering www.sciencedirect.com Scientia Iranica A (2013) 20 (1), 87–96.
- [47] Massimiliano Ferraioli “Base Isolation for Seismic Retrofitting of a Multiple Building Structure: Design, Construction, and Assessment” Hindawi Mathematical Problems in Engineering Volume 2017, Article ID 4645834, 24 pages <https://doi.org/10.1155/2017/4645834>.
- [48] ANDREW S. WHITTAKER “Seismic isolation of nuclear power plants” Nuclear Engineering and Technology, vol.46 no.5 October 2014.
- [49] Troy A. Morgan “Code-Based Design: Seismic Isolation of Buildings” Encyclopedia of Earthquake Engineering DOI 10.1007/978-3-642-36197-5_304-1# Springer-Verlag Berlin Heidelberg 2021.
- [50] Ayman A. Seleemah “Seismic response of base isolated liquid storage ground tanks” Ain Shams University Ain Shams Engineering Journal www.elsevier.com/locate/asej www.sciencedirect.com Ain Shams Engineering Journal (2011) 2, 33–42.