Analytical Study of Base Isolation- A Review

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Abstract. Now a days the rate of happening of seismic events increasing and due to that so many structures got collapsed or damaged. In order to reduce the damage to structures during earthquakes, now a days the base isolation system is widely adopted and used over the world. This paper makes a wide review on the various base isolation techniques adopted and used. Different types of isolating bearings and materials used in it are reviewed. Here the review is done for the isolation system in normal R.C buildings (regular and irregular in plan) and also for bridges. The effect of base isolation system on some historic structures is also reviewed. The various advantages and disadvantages of different isolating bearings are reviewed. Here the effect of temperature on some isolating devices are also reviewed.

1 Introduction

In now a days, the rate of seismic events gets increased and it becomes a major problem. Due to that many structures get collapsed or damaged. In order to prevent that base isolation system is widely adopted and being used all over the world. There are so many bearings are developed and used. The isolation system effectiveness can be differ for buildings regular in plan. The isolation device against seismic response for buildings and bridges can vary. The materials present in the isolation device is an importance factor in determining the property of the base isolation system. The response of base isolation system. The response of base isolation system will differ for normal structures and retrofitted structures. So day by day various kinds are new materials are developed and utilized in the base isolation system in order to increase the effectiveness of it. When a base isolation system is adopted for a structure then the temperature of that area should be analysed, because the temperature can influence the property of the materials present in the isolation system. For, steel structures some kind of different base isolation system can be adopted. Even though the base isolation system is effective, in cost range it should not be high for the use in large areas.

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1.1 Types of isolation bearings adopted and its properties

There are so many types of bearing adopted for the isolation system. The earthquake frequency in a particular area also influences the type of isolation system adopted. So, here are some reviews made on a different types of isolation bearings adopted over the world and also properties of it also reviewed.

From [1] an investigation on steel versus carbon (FREI) / Nylon (FREI) had done with bolted versus unbounded connections. In this experiment initially they have developed and characterised the high damping rubber, then with that they designed an isolator prototype for a real building. After that by compression and shear test combined and tested on the prototype. 4speciemen where taken and tested and got stress, strain relationship and also force, displacement relationship by tension test with that they got the volume of damping ratio as well. From this the prototype made of natural rubber show the identical characteristics of typical high damping elastomeric isolators. The prototype attained 150% strain and bonded FREI 6 is failed due to debonding between 150% -200%. From here the unbounded FREI is good with higher potential rate higher for low – rise building in low – cost seismic isolation system.

[2] had done an experiment with Geotechnical Seismic Isolation (GSI) on response of low – rise building. Here they used Sand Rubber Mixture (SRM) which has low shear modulus and higher damping in the layer of (GSI). They considered a two – storied building and by considering the interaction of soil structure. Also, the 2D numerical investigation based on finite element (FE) is done for analysis. They seismic response of building considered hypo-elastic formulation of sub surface materials. The main reason for choosing the SRM is because of its advantages. Soil profile taken from Roorkee town at Indo-Gangetic plain which is under the zone 4 and 5 it has high seismic intensity as per IS code. Uni-axial geogrid is adopted for 2D model and that is considered to be isotropic, homogenous with elastic-perfectly plastic material. They have taken various earthquake input motion for study. The shear force and inter-storey drift have been analysed. From this GSI system with 0.1B – 0.2B (B is footing width) with double layered geogrid reflection in seismic action of low-rise building.

From [3] the experiment carried by A. Calabrese, D. Losanno, etc. had done a base isolation device with Recycled rubber – Fibre Reinforced Bearings (RR-FRBS) for developing countries in residential buildings. The Response History Analyses (RHAs) also have been analysed for their experiment. For understanding the properties of prototype bearings, they used Finite Element Analyses (FEAs) method. They have compared their work in same building with non-conventional devices i.e. Laminated Rubber Bearing (LRBs) and Friction Pendulum Systems (FPSs). For manufacturing rubber, they have taken waste tires or industrial waste rubber and made them into chips of 50mm in size and it is reduced to 10mm size smaller. Then by desired design mix the rubber is pressed hot or cold condition. For optimizing binder polymerization hot pressing is done at 130-150 degree Celsius. From FEA for RR- FRB the lateral force – displacement is B=240mm. For a peak shear force for a bending at corner by RHAS and it is compared with peak shear force of FPS, RR- FRB, LRB isolation system. From the result the average reduction of base shear is 82%for LRB, 70% FPS and 61% RR- FRB's isolation systems. They got viscous damping of 20% at 30% shear strain for RR-FRB's. Finally, RR- FRB's are appealing extremely because of its light weight and low cost.

Author of [4] had done an experiment on the stochastic response of structures with hybrid base isolation systems in an R.C building located at solarino, Sicily. The hybrid base isolation is nothing but the combination of sliders of low friction and high damping rubber bearing. The main aim of their study is to analyse the effect of variation that is unavoidable in six-parameter values of mechanical model. This is done from the response of both hybrid

base isolation system and superstructure solarino building. The various parameter they have analysed and single degree of freedom system, high damping rubber bearing, coulomb friction model for simulating the low friction slider, a shear beam type, four degree of freedom model. Then they take an R.C building at solarino for study and trilinear hysteretic model was developed. Then by mechanic models the standard the standard deviation of isolation system was noted. For analysing the deviation, they repeatedly conducted. Then they developed constitutive equation for constant coulomb friction model and then they done the analytical solution. For doing this they have used Monte Carlo simulations. Finally, by their study they say that the identification of BIS in use is uncertain with fraught, because the material properties of BIS changer over period results in change of six parameters.

L. Casagrande [5] had done a study on innovative dampers as floor isolation systems for seismically retrofit multi storey critical facilities. The main moto of their experiment is to analyse the effectiveness use of a method used to retrofit existing and strategical buildings. They also suggest an procedure for installing the cutting-edge dampers for isolating the floor systems. Firstly, by taking the advantage of properties of shape memory alloys materials. They designed the dampers which capable of remaining in a elastic form in a low intensity dynamic events. They have used 3D finite element numerical analysis for the experimental test that is conducted at the Italian National Research Council. To achieve dissipative performances, they have also proposed visco- elastomaic dampers. First, they have done to make dampers by SMA wires. Then for the SMA damper the tensile behaviour is analysed. Then the test on visco- elastomaic rubber bearing damper is carried out. Then the reference strategic building design is carried out and the 1D modelling of SMA based and visco-elastomaic device is drawn. As a result of the study, it is obtained that FIS's integrated in structures has increase in structural strength up to 30% in columns. They also obtained decreased of 43% in accelerates 41% in displacements and 40% in inner storey drifts. Then for SMA dampers they say that it is stiffer in nature and dampers has higher dissipation capacities up to 43% and 38%. They say that SMA damper are more efficient in low rise structures (5 storey). VE damper in medium rise facilities (10 storey). Finally, then conclude that by comparing to base isolation systems, FIS's are more economic, limiting frame displacements and can be used in existing structures as a retrofitting methodology.

P. Clemente [6] analysed the effectiveness of HDRB under low energy earthquakes. In this experiment by accelerometer network the seismically isolated building is instrumented. To record the ambient vibrations fifteen seismometers is used. For this study the seismic sequence that occurred at central Italy from august 2016 to Jan 2017 were recorded. With the recorded seismic activity with different energy on the structure the earthquake effect is analysed. The epicentre of that events is long distance so that they referred that the shear strain in rubber as very low. Then they have analysed the elastic spectra of operative centre of civil protection department at falling during construction. At the construction building basement they have analysed the power spectral densities (PSB) with graph. Then by using ambient vibrations they have got the dynamic characteristics and for that they use three seismometers (s01, s02, s03) at basement and at first floor s04, s05, s06 at first floor in vertical direction, and s07, s09, s14 in Y direction. Then at top of building in centre of dome, s11 in X direction, s12 in Y direction, and s15 in vertical direction. For recording this they have placed the censor by removing of internal floating pavement and it is placed directly on concrete slab. Then in terms of velocities the ambient vibrations are recorded with sampling ratio of 200 samples(st=0.5s) and it is compared with accelerometer network. The construction and its size are showed. Then the seismic behaviours analysed and then the basement behaviour under different IA is no recorded. The epicentre of earthquake is shown. Then the time histories recorded during the earthquake of 30th oct 2016 at different section of the building at clearly drawn as graph. Then the FAS in horizontal plane are also recorded on 30th 016. They also say that the design fundamental frequency of isolated build was

0.38HZ, and experimental analysis they got different values, and the displacements are drawn as graph. They got frequency 2.5 times more than design frequency. Finally, the suggest the FE model analysis should be done.

From this author D. D. Domenico [7] had done an experiment study of base isolation system which is combined of low-friction CSSs and hysteretic gap dampers. Firstly, they say that for any isolation system which has to be effective should have a fundamental property of re-centring capability. They also say that in CSSs by the influence of friction coefficient and state of lubrication of the sliding pad the energy dissipation and re-centring capability becomes the two completive aspects. They also say the CSSs of low friction can show effective behaviour of re-centring but in turn it will undergo a large displacement. They have used a numerical simulations of 3D isolated system and the results of that are compared with result of shake table test. In their experiment process first, they have analysed the theoretical considerations for CSS, recentring capability and that is clearly shown. Then the principle of working of system combined comprising isolators and gap dampers are shown. Then the residual displacements on overall system was analysed. Then the alternative layout of isolation system combined with gap dampers are shown. Then for the proposed isolation system the seismic performance is analysed by NRHA's performed on a SDOF system. For analysing this at constant vertical load of N=1000kn was considered in NHRA's for computing corresponding mass of the isolation system. Then the CSS parameter and ground motion records are analysed. And then the time history response of CSS combined with gap damper are recorded. Then the displacements of that are shown in graph. Then they have drawn a bar chart consisting of different values of radius of curvature and friction coefficient. Then velocity and friction coefficient graph is drawn. Finally, by their study the say that the combined isolation system has a satisfactory energy dissipation which reduce the displacement demand with recentring capability high. Finally, they suggest that before implementing this system to real ground factor the inherent cumulative damage effects to hysteric dampers with conventional steel elements should be analysed.

In this paper [8] had compared the seismic response of a multi-storey RC building base isolated by LRBs with same RC building of base isolated by an ignorative seismic isolator which they called HDHSI. They say that the horel HDHSI is obtained by assembling in a series of an LRB and a FS which has high friction coefficient. The base isolation system is done by elastomeric materials and steel-Teflon bearings. The non-linear behaviour of the isolation system is analysed by hysteretic cycles of isolators, then firstly they have analysed LRB which is a composite material of vulcanized rubber layers interspersed with steel layers. For the LRB by using the linear elastic term and hysteretic term the reacting by using the linear elastic term and hysteretic term the reacting force of it was explored. Then the friction slider (FS) isolator is analysed which is a composite material of elastomeric rubber disk and sliding plater developing the friction between contact surfaces. By PTFE (Teflon) bearings and steel the sliding surface are made. After that the mathematical modelling for the base isolated system is derived. The HDHSI base isolation device is modelled by a single degree of freedom system. Then the mechanical behaviour of HDHSI base isolation device at different phases is analysed and shown. Then for the HDHSI base isolation device the hysteretic cycle is analysed and shown. Then the HDHSI base isolated device the finite a nonlinear finite element N line" friction pendulum Isolator" have been adopted depending on sliding speed and the minimum and maximum parameters are shown. Then the proposed HDHSI base isolated system is applied to the multi-storey r.c building which is subjected to extreme seismic actions. Then the hysteric cycles of HDHSI base isolators are mentioned separately and the floor plan off building is mentioned. Various parameters are considered as mentioned in table 1. Then for different limit state the elastic response spectrum in terms of acceleration are shown in terms of displacement. Then at last they have compared the HDHSI system with traditional base isolation systems. Then the various comparative

analysis are done. Finally by their experiment they say that compared to traditional LRB system which is not equipped with a sliding mechanism, the HDHSI system has shown a particular efficient in counteracting seismic events which is characterised by high intensity and or anomalous for frequency contact.

Here they [9]done an experimental study on the base isolation systems for the seismic retrofitting of RC framed buildings with soft-storey subjected to near fault earthquakes. Here to justify the nonlinear seismic behaviour of masonry filled base isolated RC framed structures first a six-storey RC framed building is designed with fixed base under medium risk zone using former Italian seismic code and it is retrofitted by intensity of base-isolation system with elastomeric and sliding bearings. By considering three structural models the failure mechanism of totally and partly infilled structure are compared. The three structural models are bare structure with non-structural MIs infilled structure with in elevation uniform distribution of structural MIs infilled structure with in-elevation uneven distribution of structural MIs. By pumped plasticity model the non-linear dynamic analysis of original (fixed base) and retrofired structures is carried out. Pivot hysteretic model is used to predict non-linear force displacement. By starting the process firstly, they worked out the properties of fixed base structures and the dimensions of it are shown. Then they have analysed the retrofitted base isolated building. The section plan of base isolated retrofitted structure is shown. Then for the masonry fills the non-linear modelling is done and it is shown. Then for the structure the monotony curves for the masonry infills (MIs)are analysed and drawn. Then the numerical results are carried out and various data are selected for near fault earthquakes and that is mentioned. Finally, by their study they say that the base isolation with elastomeric bearing is much efficient for seismic retrofitting of fixed base structure than other base-isolation system. The assumption they made bar frame model show dull performance under near fault ground motions. They also say that MIs is not well distributed so the heavy damage in base isolated structure subjected to near fault earthquakes is expected.

In this paper A. Calabrese [10] had done an investigative process theoretically and experimentally on SPSI system that is used to protect the NPP equipment large against the seismic activity and loads of shock and vibration. Firstly, they have done an analysis and design of SPSI has been done. The major composition of SPSI is plastic damper, Pendulum bars and fastening assembler. Then by using the graph the characteristic of force is analysed for the plastic damper and the bilinear property is also examined. Then by using finite element analysis a model is done for a core. Then the force and horizontal displacements are found saturated. Then the full-scale practical testing setup is done and conducted. Then the relative and dynamic movements are taken out. Finally, by the result of their study the value got for the seismic platform are 1 gm/s2 as horizontal acceleration and 0.5gm/s2 as vertical acceleration and 0.691 gm/s2 as horizontal speed and 0.11m as horizontal displacement. Finally, they conclude that the dampers used permitted them to attain the level of required dissipation.

In this paper they [11] had done a study on the Finite Element Analysis (FEAs) result to understand the response of FRBs which is subjected to combined shear and axial loads. They also aimed at working out the FRBs capacity of lateral displacements. Here 2D analysis is used. First the various properties of FRBs and it deformed shape during shear tests are analysed. Then for the unbounded FRBs the capacity of lateral displacement is found out and then the post-buckling and buckling analysing is carried out. Then for the FRBs the FEAs is done and that the value of bulk modulus and shear modulus of the rubber is carried out. Then the numerical and analytical results are compared. By the result of their study, they say that the deformation capacity at pea shear reduces due to the increase in FRB vertical pressure. They also say that the bearings maximum capacity of displacement can be modified by the axial pressure magnitudes. The rubbers shear modulus capacity plays a major role in increased the bearings capacity of peak strain and stress. They also say that the rubbers bulk

modulus factor is independent of the FRBs capacity of peak stress and strain. Finally, they suggest that still more studies should be carried out additionally for analysing the FRBs failure criteria and damaging property at combined axial and lateral loads.

The author of this paper [12] had done an experiment on FREIs in which the main aim is to tuning of lateral response of unbounded FREIs. For modification of lateral response of FREIs and stiffness of FREIs a Finite Element Analysis (FEAs) is carried out. In the first stage of process by the unbounded FREIs is tested and by that the resultant forces and stress distribution are made out. Then with FEA the bearings are tested with four cases (i.e., no holes, hole, 2 holes, 3 holes). At the end they say that the lateral holes present helps in modifying the bearings vertical response. They also say that less than 20% only the reinforcement stress increases in bearing by cutting a hole. Finally, by their work they suggest that additional studies should be carried out to analyse the 3D response of the FREIs.

P. C. Ruano [13] had done an experimental study for analysing the mechanical properties like horizontal and vertical stiffness and damping capacity of the unbounded circular fibre reinforced elastomeric bearings. It mainly focuses on the shape geometry effect and material used in fibre reinforcement layers. Quasi-Static cyclic test was carried out to analyse the compression, deflection, and frequency value. In the first step they analysed the vertical and horizontal behaviour then compression test is carried out. Then the cyclic lateral tests are done and by that the displacement values are made out. Then with the result of their study they compared with elastomeric bearing of square shape. Finally, by their study they say that based on the compressive had only the value of compression modulus and vertical stiffness of circular fibre reinforcement elastic bearing depends. They also say the horizontal behaviour of the circular FREBs are somewhat better than FREBs of square shape.

A. Khaloo [14]had done a study on the steel reinforced elastomeric bearings. Here for SREBs both the finite element modelling and the experimental test were carried out. Here the test was conducted for both case of SRBs (i.e. bounded and unbounded) at 125% of maximum shear strains of total bearings height of rubber, which is far greater than the induced service-load strains. For the SREBs the shim thickness, vertical loading, shape factor also analysed. In the process of experiment first the steel shims effect on bearing is noted. Then the SREB of deformed and undeformed shape is analysed. Then the damping factor of SREBs is carried out by hysteretic analysis. Then for the unbounded SREBs the frictional behaviour is analysed. In the numerical modelling process the finite element modelling is done and the calibration of that is also carried out. Then in the parametric study process the SREBs hysteretic behaviour is analysed. Then the vertical load influence and shape factor are noted out and effect of steel shim thickness is also analysed. Then for the steel shims the rupture and stress distribution analysis is carried out. Then bilinear model derivation is carried out. As a result of the study, they say that the SREBs can resist 125% of shear strain and that is double time equal to the service load demands. Even though the stress distribution differs in both bounded and unbounded SREBs it shows same hysteretic behaviour.

Here [15] had done an experimental study on the steel laminated rubber bearings in a way it is tend to undergo a combination of shear strain and axial loads. Here for the test on the bearings they have taken the values of axial displacement ranges from 4% compression and up to tension of 90% and 210% of shear stress and 0.0205 rad of rotations. In the first step of process the mechanical and geometric property of steel-laminated rubber bearings is analysed. Then time history analysis for the seismic activity is noted. Then the steel shim yielding is worked out due to flexural deflection and rotation of isolator. As a result of their study, they say that the elastomeric behaviour got degraded due to the steel shim rotation. The rotation of steel shim also causes plastic behaviour and it majority influence the behaviour of steel laminated rubber bearing. They conclude that the steel shims yielding point was not exceeded for the time histories and benchmark isolator combined.

R. Rahnavard [16]had done an experiment o steel rubber base isolator with rubber cores of single and multiple and mainly the lateral stability of that is found out. For making the elastomeric bearing model the method of finite element is used. For doing this analysis the dynamic analysis, reduced area formula and quasi-static methods are used and a comparison of their results are carried out. The method of oyden is applied to model the properties of rubber material. As a result of the experiment, it is said that the quasi and static methods give out a similar result. By comparing the result, it is said the quasi-static method for stability measuring shows more effectiveness. By stability analysis it is said that single and multiple core rubbers make a increase in stability of the isolator because more critical loads.

In this study [17] had done an experiment on circular FREIs. For this study sixteen circular FREIs is taken and for that the 3D parametric numerical FEA is done. By using pressure approach method various solutions are got. As result of the analysis, it is said that the end boundary effect plays an important contribution in the bearings vertical response. By comparing the analytical solution and FEA result it is said that the result of vertical stiffness of bearing is good in FEA.

In this experiment author [18]had implemented a perfectly designed self-centring hysteretic dampers on a industrial steel structure that is retrofitted. First the linear and non-linear modelling process is carried out and the seismic vulnerability is obtained by using non-linear and incremental dynamic analysis. As a result of the study, it is said that maximum and residual displacements values are powered by the post-elastic stiffness. The yielding force influences the energy dissipation of SSCDs. Finally, it is said that the maximum and residual displacements get reduced by the increase of yielding force in a view of displacement points.

In this paper author [19] had done a study on the novel fibre reinforced isolators. In this the experimental test and analytical modelling is carried out. Here for the unbounded isolator the carbon and polyester high damping rubbers are used. The proto types are made and it is made into shear and comparison land test. As a result of experiment, it is said the FREIs horizontal behaviour is satisfactory. They also suggest to conduct a solubility analysis and should improve the process of manufacturing.

Here [20] , the new type of semi-active (hybrid) isolator is studied with the help of analysis simulation software for analysing and modelling. The building is examined with 2cases, and it undergoes with different seismic waves with the new hybrid isolator for getting tested. From we clearly know that the final storey of the building undergoes a most dynamic load comparing with the base floor. It shows that displacement increases from ground storey to the top storey of the building. From the study we clearly know that the very good improvement in using the semi active isolator for the buildings in seismic area. And also, it decreases the building structural drift, flexibility, reduce the isolation and its base shear. These semi-active isolators prevent the massive damage of the building during seismic times.

This study [21] gives the solution for rubber bearing isolators lateral instability and tensile strength. Lateral movement of floor and floor drifts are reduced by the isolators. Generally, for withstanding the gravity loads the isolators are designed fixed in vertical direction and flexible in horizontal direction. Here, new variety of roller type isolators are used for solving the elastomeric problems. Roller type isolator are capable to resist the tension in it. From analysis there is no risk are shown in it and also it shows the behaviour of seismic isolator as well. This is used for increases the performance of structure in seismic time.

In this [22]study a separated structure is split in a vertical isolation plane of various structures are joined with a technique and its response are compared with a non-separated structure, from this analysis the correlation of isolation ration and parameters link in the USI systems response controlled are known. Investigation on non-linear viscous damper Di equalizing the viscous damper force on various velocity exponents with comparable linear viscous damper. But this result not mention a needed activity of NVDs over LVD still

parameter proportional to mass with stiffness ration carry to acceptable range of seismic response in 2 types of dampers, find importantly low-velocity exponent of NVD application is not recommended.

F. D. A. Donato Cancellara [23] get the dynamic behaviour of base isolation structure's characteristics in high irregularity. They take a HDRB isolators and placed it in parallel to friction slider isolators. We can know which of this analysis is most conservative to isolated structures in which features it is more conservative. The results are taken from the deformation and stresses occurred in the base isolated structure from the dynamic analysis the response spectrum is performed well while comparing with non-linear dynamic analysis.

This paper [24] deals with the LRB isolated structures reliability mainly it deals with the 2 folds they use the genetic algorithm for the studying purpose from this algorithm we get different approaches that are used for developing the reliability curves of the building which are isolated with various system of isolation.

Here [25]the building is isolated with SMA-LRB system and that buildings are seismic activities and it is observed in the process of bi-objectives. The strength of SMA-LRB is put forward in various seismic activities. From that we get the confirmation of magnify strength in different time of isolation at larger intensities of earth quake.

D. D. Domenico, [26] the non-orthodox process of the joining the tuned-mass damper (TMD) with base isolation at underground under were the base floor were isolation is done, is experimented for understanding the performance of the building. From this system we get the dominance of the based-isolated building and orthodox upper of the base isolation are early visible. According to author this system is very useful for new & old buildings which are need a great amount of protection from the seismic activity mainly in the public buildings.

In metro regions [27], the buildings need to with stand the vibration induced from the metro laminated rubber bearings are used but they are not studied deeply in this area. 4 types of LRB are used like think and thick. From the result it shows both the 4 types of LRBs are stable and in various intensities of vibration but both thick natural rubbers bearing and thick HDRB are stable when comparing with thin rubber bearing.

Here [28] base isolators were considered LRB, FPB, HDRB and energy dissipation instrument as friction damper (FD). Unique result from this, the combines isolations with FD performance is way better than the singly system. The base isolator with FD achieves a great result and the drift of inter-storey is limiting unaccompanied with the acceleration in combined isolation system. When comparing the LRB and HDRB with the FD & FDB the elastomer bearing is way better.

From [29] here the implementation of pure friction system supplemented with SMA retainer to a framed structure for improvement in multi-objective. The behaviour of the design is verified with a different seismic motion. SMA transformation gives a more strength for different seismic loading. The SMA-PI system's optimization clearly mentions the strength.

FNCATB based S-FBI provides a more workability in wide temperature areas. This isolator is providing an un-expected response to the seismic waves comparing with convention FPS. And it [30] also provides a wet-benefit in shows the great result for adopting it.

It states that [31] the lead core rubber bearing property are examined in the base of 3 form, numerical simulation is used to find the parameters. From the 3 base lead core radius place a major role in disturbing the performance as well as number of rubber layer play a minimum disturb to their activities. Shear deformation is used to release the excess energy in the lead core at the meanwhile it increases the damping ratio. So, while making the isolations it should be considered.

1.2 Effect of material present in the isolating devices

The type of material a used in the isolating device determines the strength of it. The particular material used in isolator can determine the property of the isolator. Here some review is made on effect of some particular material used in the isolation system.

Here [32] a new bearing was developed and tested with and without lead in Laminated Rubber Bearings (LRB). They conducted an elastomeric bearing design by using codes and also with visual basic software. For base isolation system they have a following needs, they are ability to sustain gravity loads, low horizontal stiffness for lengthen the fundamental period of time, large vertical stiffness for minimize amplification, energy dissipation capacity, sufficient initial stiffness for avoiding unwanted vibrations. For finding the force deflection characteristics different test are conducted in various sequence and cycles in the isolators. For examine the quality of elastomeric bearing, vertical load of 240kN is applied to Laminated Lead Rubber Bearing (LLRB) by using UTM machine for compressive test. From that deflection is found. Lateral horizontal stiffness is 55 times smaller than the founded vertical stiffness(48000kN). Then for the specimen combined shear and compression test were carried by using UTM. From that the max. lateral load of 75Kn and displacement of 85mm were taken along with that quasi-static test also conducted. Then result between LRB & LLRB were understood for lead role in isolators and also the energy dissipation of LLRB is much greater than LRB. So, providing the lead increasing and recreating the energy dissipation capacity. The difference between the energy dissipation of LLRB TO LRB IS 80% to 85%. So, the LLRB use is gradually increasing in the world for protecting the structure from earthquake.

[33] had analysed the seismic isolation using Scrap Tire Rubber Pads (STRP). In this research they have taken a 3- storey building and it is base isolated with STRP. They have compared the base isolated 3-storey building with a fixed base (without isolation) structure by using MATLAB they have calculated the natural frequencies and mode shapes for both structures. In the methodology they have taken a school building which is in seismic zone -5 and containing a medium stiff soil. By using mass matrix and stiffness matrix they have calculated the mass and stiffness of the building. then the building of two causes is analysed in MATLAB. From that fundamental frequency and corresponding time period is calculated. As a result of their study, they have got a fundamental frequency as 1.877Cps and its time period as 0.533sec for fixed base type building. They got a frequency as 0.2772Cps and the corresponding time period as 3.608S for isolated base building. Finally, they say that isolation using STRP is very efficient.

Similarly, [34] they done a study for testing on FRB's for analyse the durability and performance for long term. Then in both shear and compression they studied the effects of aging of FRB'S. Then a benchmark base isolated building is taken as reference and for that the effect of aging of bearing is calculated. Then finally by the result of new and aged FRB'S the result is compared with conventional steel reinforced bearings. For the testing of FRB'S they have studied the oxidation of rubber and they have studied the various factors that influence the aging of LRB'S. Then the accelerated aging test by international standards are carried out. Then the compression test they obtained the vertical stiffness of bearings. Then shear test is conducted and a graph are drawn to analyse them. Then for the taken benchmark building the test is carried out and by the finite element analysis the properties of every floor of building during test is analysed and with that the column intensity and the drift are recorded. The torsional response is calculated. Finally, by their study they say the deformation reduces due to significant aging of devices and the value for neoprene being is 67% approx. than the HDNR bearings approx. 15%. They say that new isolates the aged bearing and stiffer. The aging of HDNR increase approx. 26% due to aging under far-field events. Finally, by their result they conclude that it was assumed that fibre reinforcements do not alter the aging characteristics of rubber based denies.

According author [35] this system consists of HDRB which is strengthened by glass fibre fabrics. For analysing the model numerical investigation and finite element analysis are used for checking its performance. This method is implemented inn a storage tank with certain stage. From that we obtain a result of what we need and it is verified.

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