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ANALYTICAL COMPARISON OF A G+8 STORY RESIDENTIAL BUILDING WITH FIXED BASE AND BASE ISOLATION

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Abstract - *The requirement for taller structure in construction and assets business is increasing everywhere the world. These structures square measure versatile and made as lightweight as potential, that have low worth of damping, makes them prone to unwanted vibration. This vibration creates drawback to usefulness demand of the structure and conjointly cut back structural integrity with potentialities of failure. during this study reinforce concrete structures square measure taken for unstable performance analysis. This RC building is sculptural with completely different structural system like base isolator with use of economic pc software package. Then numerous ground motion knowledge is applied to the building model to gauge structural response. Linear time history analysis is allotted for building model with every system and therefore the results of unstable response of every of system is compared with different system. Time history analysis results shows that building with base isolation shows lesser displacement and lesser drift, lesser overturning moment, lesser story shear than fix base building.*

Key Words: **Lead rubber bearing base isolation, Time history analysis, Time history, Base shear, Overturning moment.**

1. INTRODUCTION

Base Isolation could be a technique within which structure of a building is separated from its sub-structure by providing a suspension between them. Earthquake resistant is provided to the structure mistreatment this mechanism. During this system, the building is decoupled from the lateral ground motion iatrogenic by the earthquake, by providing a vertical element with a high stiffness that acts as an affiliation between the structure and therefore the sub-structure. In straightforward word it is often said that there's no result of ground motion on structure, if the structure is floating on its base. It is a Passive management device that consists of a structure, isolation, foundation and soil. During this isolation system is between structure and foundation to cut back the dynamic response of the structure. During this system ground is allowed to maneuver freely while not poignant the structure and while not transferring the motion. In ideal case the separation ought to be total however in sensible it's insufferable, there ought to be very little contact between structure and substructure. It are often placed within the structure throughout the development stage or are often placed whereas maintenance as a unstable retrofitting. The most idea of base isolation is to cut back input energy, which ends in reduction of acceleration within the structure. The time interval of structure against earthquake will increase thanks to increase in elementary period of structure.

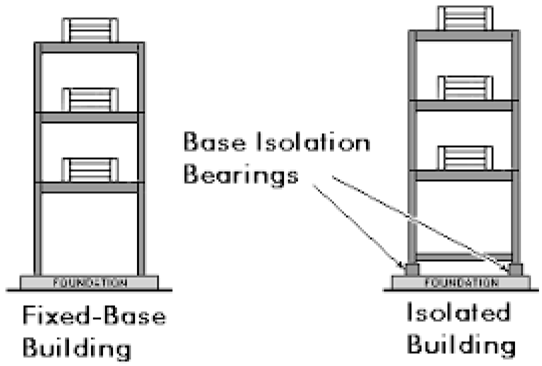


Fig1.1: Fixed Base Building and Base Isolated Building

1.1 PRINCIPAL OF BASE ISOLATION

The fundamental principal of base isolation system is to rectify the response of the structure in order that the bottom will move below the structure while not transferring these motions into the construction. In a perfect system for the supple this separation would be total. However within the existing world there's a desire to own some contact between the construction and sub structure.

A structure that's dead supple means that has AN infinite period of time. Once the substructure moves there'll be zero acceleration influence within the structure, and therefore the relative displacement between the structure and substructure are coequal to the bottom displacement between the structure and therefore the ground are capable ground displacement the structure won't move with the bottom motion.

All the present structures don't seem to be dead rigid and dead versatile, that the response to ground motion is between the 2 extreme as shown in fig-1.1.For the time periods between zero and eternity, the most accelerations and relative displacements to the bottom is depends on the earthquake as shown in fig.1.1

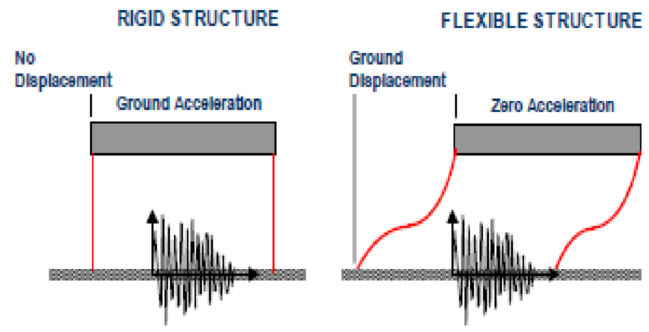


Fig 1.2: Transmission of the Motion

For most of the earthquakes there'll be a gamut of your time periods during which the acceleration within the structure are going to be amplified on the far side the bounds of the utmost ground acceleration. The relative displacement can ne'er exceed the intense ground acceleration that's infinite amount displacement however there's some exclusion to the current notably for soft web and site that is found about to the fault generates the earthquake.

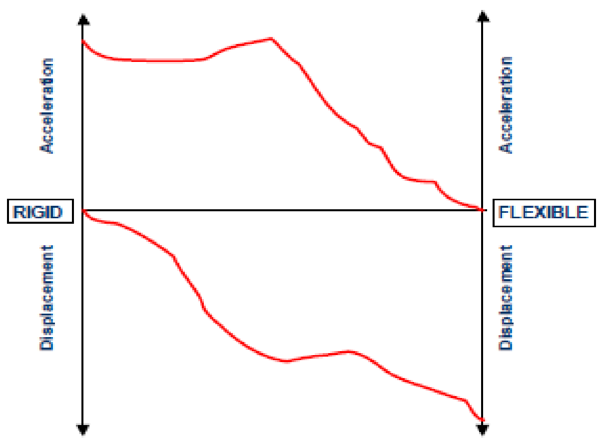


Fig 1.3: Displacement behavior of flexible and rigid structure.

1.2 BASIC COMPONENTS OF BASE ISOLATOR

The base isolated structure consists of many parts as pictured in Fig. 1.4. a quick introduction of element system square measure conferred as follows

1) Isolation system- The assorted isolators, that cut back the amount period of time period, fundamental quantity fundamental measure} shift of the structure to a period; vary of two to three sec, with the isolation system. In base isolation structure solely isolation system shows non linear behavior, whereas structure and soil system square measure shows linear behavior.

2) Structural system- This method carries with it structural element of structure still as foundation. The in Hume level drift for isolated structure is extremely low thus, that the super structure will handily be assume to behave like linear elastic manner.

3) Soil system- The sub soil system exhibits their own stiffness and damping properties which can or might not have an effect on the response of the structure that is situated upon it. This influence of the interaction between the soil and structure becomes important just in case of loose under soil strata.

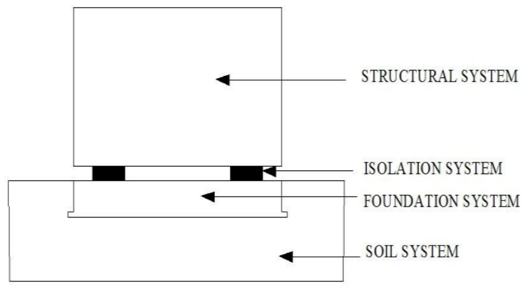
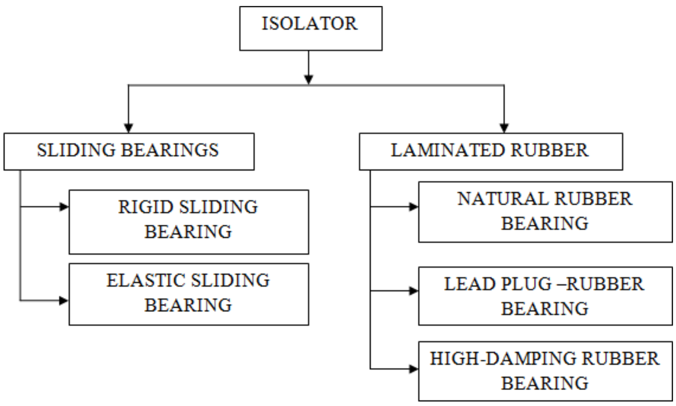


Fig 1.4: Basic Elements of a Base Isolated Structure

2. TYPES OF ISOLATOR



2.1 Elastomeric Bearings-

In Bridge superstructures these bearings square measure used, which frequently endure substantial dimensional and form changes thanks to up down in temperature. additional recently their use has been extended to the unstable isolation of buildings and different structures. Elastomeric, nonleaded-rubber bearings square measure out there as either low-damping natural rubber bearing

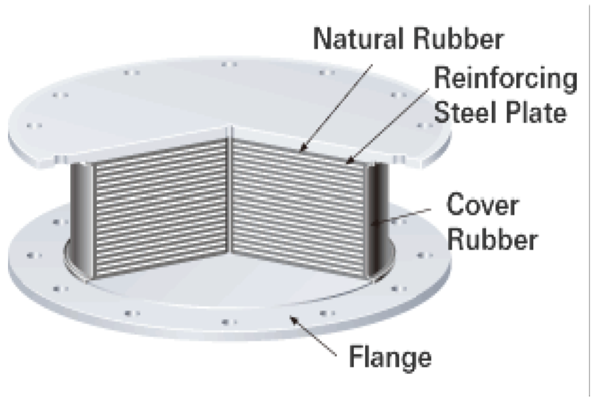


Fig1.5: Elastomeric Bearing

2.2 Lead-Plug Bearings

Lead-plug bearings are made up of low-damping elastomers and lead cores with diameters between 15% to 33% of the bonded diameter of the bearing. Laminated- rubber bearings supplies the required displacements for seismic isolation. By combining laminated-rubber bearings with a lead-plug insert, which provides hysteretic energy dissipation, the damping required for a successful seismic isolation system can be incorporated in a single compact component. Thus, one device will support the structure vertically, to provide the horizontal flexibility together with the applied restoring force and to provide the required hysteretic damping. The maximum shear strain range for lead-plug bearings varies as a function of manufacturer but is generally between 125% and 200%.. LRB isolators have cylindrical rubber bearings, which are reinforced with steel shims. Shims and rubber is placed as alternate layers. Steel plates are also provided at the two ends of the isolator. The steel shims boost the load carrying capacity, thus the structure is stiff under vertical loads and flexible under horizontal loads.

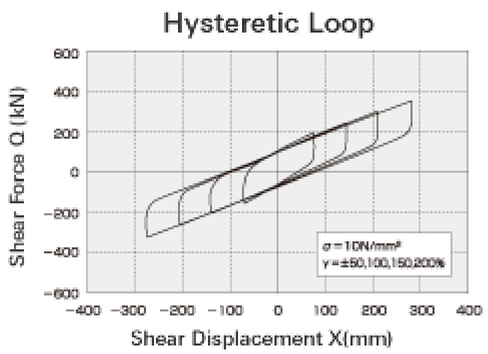


Fig 1.6: Lead Rubber Bearing

2.3 Friction Pendulum System

The concept of sliding bearings is also combined with the concept of a pendulum type response, obtaining a conceptually interesting seismic isolation system known as a friction pendulum system. The slider is faced with a bearing material which when in contact with the polished chrome surface, results in a maximum sliding friction coefficient of the order of 0.1 or less at high velocity of sliding and a minimum friction coefficient of the order of 0.05 or less for very low velocities of sliding. The dependency of coefficient of friction on velocity is a characteristic of Teflon-type materials. (Kelly J M, 1996)

The system acts like a fuse that is activate only when the earthquake forces overcome the static value of friction. Once set in motion, the bearing develops a lateral force equal to the combination of the mobilized frictional force and the restoring force that develops as a result of the induced rising of the structure along the spherical surface. If the friction is neglected, the equation of motion of the system is similar to the equation of motion of a pendulum, with equal mass and length equal to the radius of curvature of the spherical surface. The seismic isolation is achieve by shifting the natural period of the structure. The natural period is control by selection of the radius of curvature of the concave surface. The enclosing cylinder of the isolator provides a lateral displacement restraint and protects the interior components from environmental contamination.

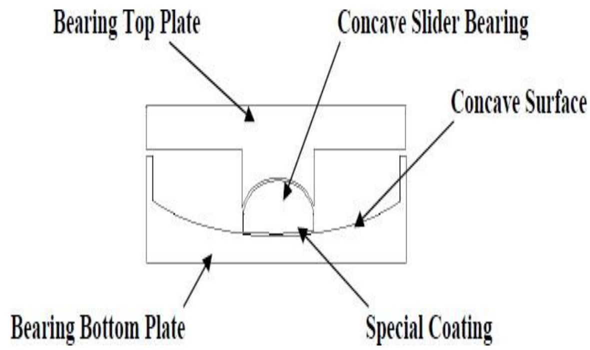


Fig 1.7: Friction Pendulum System

3. MATERIAL PROPERTIES & SPECIFICATIONS

S. No.	Specifications		Size
1	Plan Dimensions (X× Y)		30 m × 24 m
2	Floor to Floor Height (Z)		3 m
3	Total Height of Building (G+ 8)		27 m
4	Type of Structure		SMRF
5	Soil Type (as per IS: 1893 (Part-1) – 2002)		Medium
6	Response Reduction Factor		5
7	Importance Factor		1
8	Seismic Zone Factor		0.36 (Zone V)
9	Grade of Concrete & Steel		M 25 & Fe 415
10	Beam Size		0.30 m × 0.50 m
11	Column Size		0.30 m × 0.60 m
12	Slab Thickness		0.150 m
13	Wall Thickness		0.200 m
14	Staircase	Rise	0.120 m
		Thread	0.350 m
		Width	1.5 m
		Stringer	0.160 m

<table>
<tr><td>15</td><td colspan="2">Load Combination</td><td>According to IS : 1893 (Part 1) :2002</td></tr>
<tr><td rowspan="4">16</td><td rowspan="4">Loads Applied</td><td>Dead Load</td><td>Calculated as per Self Weight</td></tr>
<tr><td>Floor Finish</td><td>1 KN/m²</td></tr>
<tr><td>Live Load</td><td>3 KN/m²</td></tr>
<tr><td>Seismic Load</td><td>Calculated as per IS: 1893 (Part-1) – 2002</td></tr>
</table>

4. CALCULATION OF BASE ISOLATION

STEP 1: Estimation of Effective Stiffness of base isolators

$T_D = 2\pi\sqrt{\frac{W}{K_D \times g}}$ $K_D = 108632.16$ KN/m

STEP 2: Calculation of Design Displacement

$D_D = \frac{g \times S_{D1} \times T_D}{4\pi^2 \times B_D} = 0.133$ m

STEP 3: Determination of Thickness of LRB

$t_r = \frac{D_D}{\gamma_{max}} = 0.089$ m

Assuming the end plates as 25 mm thick and steel shim as 2 mm each

Total Height, h = $2 \times 25 + 5 \times 20 + 4 \times 2 = 158$ mm

The steel shim will have a diameter of 650 mm giving 5 mm cover.

$F_Y = Q_d + K_2 \times D_Y = 3777.91$ KN

Where, F_Y = Yield Strength

$V_b = K_{Dmax} \times D_D = 15892.89$ KN

$V_s = \frac{K_{Dmax} \times D_D}{R_1} = 7946.44$ KN

Where, V_b = Minimum base shear strength below isolation interface

V_s = Minimum base shear strength above isolation interface

R_1 = Response modification coefficient

R_1 = 2 (For SMRF) (ASCE 7-05 Table 12.2-1)

5. RESULTS

5.1 Story Displacement

Displacements of different stories were determined using Time History Analysis in x and y direction for fixed base building, base isolated building. Tables and graphs are shown to determine the efficiency of isolator reduction in response.

Table 5.1 Story displacement in x direction due to EX

Story	Elevation	Fixed Base Building	Base Isolated
	m	mm	mm
Story 9	27	80.40	90.34
Story 8	24	76.96	89.05
Story 7	21	70.01	85.26
Story 6	18	62.83	78.93
Story 5	15	52.94	70.59
Story 4	12	41.89	60.82
Story 3	9	30.11	50.08
Story 2	6	18.18	38.52
Story 1	3	6.79	25.06
Base Isolation	0.158	0	2.81

Table 5.2 Story displacement in y direction due to EY

Story	Elevation	Fixed Base Building	Base Isolated
	m	mm	mm
Story 9	27	130.77	152.12
Story 8	24	125.79	150.94
Story 7	21	116.45	145.06
Story 6	18	103.57	135.03
Story 5	15	88.10	121.93
Story 4	12	70.87	106.70
Story 3	9	52.54	90.12
Story 2	6	33.66	72.75
Story 1	3	14.81	53.30
Base Isolation	0.158	0	2.78

5.2 Time Period

Time Period of buildings was determined using Time History Analysis for fixed base building, base isolated building. Tables and graphs are shown to determine the efficiency of isolator reduction in response.

Table 5.3: Time Period of buildings from time history analysis

Fixed Base Building	Base Isolated
Sec	Sec
1.802	2.248

5.3 Overturning Moments

Overturning Moments of different stories were determined using Time History Analysis for fixed base building, base isolated building. Tables and graphs are shown to determine the efficiency of isolator reduction in response.

Table 5.4: Overturning Moments of building from time history analysis

Story	Elevation	Fixed Base Building	Base Isolated
	m	KN-m	KN-m
Story 9	27	0.0054	0.0022
Story 8	24	0.4063	0.233
Story 7	21	1.347	0.7795
Story 6	18	2.7969	1.6301
Story 5	15	4.71	2.7674
Story 4	12	7.0267	4.1685
Story 3	9	9.6756	5.8054
Story 2	6	12.5755	7.646
Story 1	3	15.638	9.6538
Base Isolation	0.158	18.7718	0

5.4 Story Drift

Shear of different stories were determined using Time History Analysis for fixed base building, base isolated building. Tables and graphs are shown to determine the efficiency of isolator reduction in response.

Table 5.5: Story Drift from time history analysis in x direction due to EX

Story	Elevation	Fixed Base Building	Base Isolated
	m	KN	KN
Story 9	27	0.1311	0.0759
Story 8	24	0.311	0.1811
Story 7	21	0.4808	0.2825
Story 6	18	0.6354	0.3781
Story 5	15	0.7702	0.4662
Story 4	12	0.8813	0.5449
Story 3	9	0.9653	0.613
Story 2	6	1.0202	0.669
Story 1	3	1.0446	0.7105
Base Isolation	0.158	0	0

Table 5.6: Story Drift from time history analysis in y direction due to EY

Story	Elevation	Fixed Base Building	Base Isolated
	m	mm	mm
Story 9	27	0.001661	0.000409
Story 8	24	0.003115	0.001959
Story 7	21	0.004293	0.003343
Story 6	18	0.005155	0.004368
Story 5	15	0.005745	0.005077
Story 4	12	0.00611	0.005525
Story 3	9	0.006293	0.005792
Story 2	6	0.006286	0.006491
Story 1	3	0.004938	0.017002
Base Isolation	0.158	0	0

6. CONCLUSIONS

1. Analytical study has been done on a building by applying Base Isolation separately; it has seen that displacement in base isolation increases while in Fixe base building.
2. Time period of base isolated building is greater than fixed base building which gives more time for the structure to react during earthquake.
3. It is clear that base isolation reduces the overturning moment of the structure as compared to fixed base building, due to which more moment will be required to turn the building, which makes building more stable and resistant towards earthquake.
4. It has seen that story shear in base isolation decreases while in story shear increases as compared to fixed base building.
5. It is clear that base isolation reduces the story drift of the structure in higher stories as compared to fixed base building, due to which makes structure safe against earthquake.
6. There is reduction in base shear of base isolated building while in fixed base building and base shear remains same. Due to which the maximum lateral forces in base isolated building due to ground motion decreases at base of the building, which makes the structure more stable.

7. FUTURE SCOPE

In current study base isolation of same material is placed at every column, it can also be analyzed by installing base isolation at external and inner column with different material.

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