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# STUDY ON LEAD RUBBER BEARING LOCATED AT DIFFERENT HEIGHT OF BASEMENT STORIED BUILDING

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**Abstract:** In a Last few years, Base isolation is an alternate approach than the specified ones. It depends on the idea, which decreasing the seismic requests as opposed to expanding the earthquake resistance limit of the structure. Then again, use of base isolators to the structure is decrease flexible base shear by moving time of the structure and give better performing structure that will remain elastic in vast earthquakes. The paper studies the efficiency of seismic isolation system in form of lead rubber bearing installed at different heights of buildings with basement stories. This base isolation study along with seismic analysis is done by response spectrum analysis with E tabs software and response of structure like story displacement, drift, story shear were observed. An overall comparison of G + 4 with 2 storied basement with different aspect ratio of structure.

**Keywords** Response Spectrum, base isolator, story shear, aspect ratio, stiffness

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**INTRODUCTION**

1. There are two types of isolators given in detailed in literature review.

1.1 Lead Rubber Bearing Isolator: The LRB was invented in New Zealand in 1975 and has been utilized broadly in New Zealand, Japan and United States. The steel plates in the bearing power the lead connect to distort to shear. This bearing gives a flexible re-establishing power and furthermore, by choice of the fitting size of lead attachment, produces required measure of damping. As appeared in Figure 1. Performance of LRB is kept up amid rehashed solid seismic tremors, with appropriate sturdiness. (O. V. Mkrtycheva, 2014)

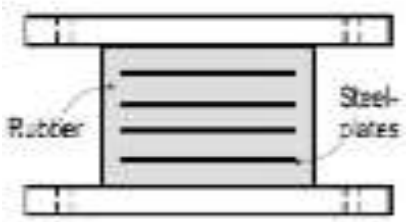


**Figure 1 Lead Rubber Bearing**

1.2 Friction Pendulum System: Sliding friction pendulum isolation system is one type of flexible isolation system suitable for small to large scale buildings. It combines a sliding action and a restoring force by geometry. The significant components of the bearing are the stainless steel concave surface and self-lubricating articulating slider shown in Figure 2. The surface is generally coated in Teflon, which provides a low friction coefficient and there by decreases the effective lateral stiffness, achieving required period shift. The outer edge of the sliding surface has a steel lip which restrains slider displacement to a specific range.

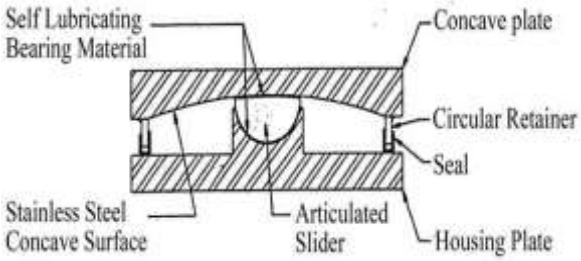


**Figure 2: Friction Pendulum System**

Seismic analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment in regions where earthquakes are prevalent.

**Equivalent Static Analysis**

Linear static analysis or equivalent static analysis can only be used for regular structure with limited height. All design against seismic loads must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is often sufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings. It begins with an estimation of base shear load and its distribution on each story calculated by using formulas given in the code. The base shear is the total horizontal force on the structure which is calculated on the basis of structure mass and fundamental period of vibration and corresponding mode shape. (Rasna P, 2018)

**Non-Linear Dynamic Analysis**

A non-linear dynamic analysis or inelastic time history analysis describes the actual behaviour of the structure during an earthquake. The method is based on the direct numerical integration of the motion differential equations by considering the elasto-plastic deformation of the structure element. This method captures the effect of amplification due to resonance, the variation of displacements at diverse levels of a frame, an increase of motion duration and a tendency of regularization of movements result as far as the level increases from bottom to top.(Rasna P, 2018)

**LITERATURE REVIEW**

1. M. Sarkisian, E.Long, D. Shook, A. Diaz:

The author gives a new paradigm in residential creation, and consists of two apartment homes, 12 and six testimonies excessive, separated by using a non-public courtyard at floor level, in which communal spaces are combined with retails and restaurants. Both residential homes percentage a seismic base isolation device below the primary ground, and three basement stages underneath with resident and public parking. The fundamental superstructure factors are completely built with concrete, imparting a post-tensioned flat slab machine, strengthened concrete columns and reinforced concrete shear wall cores. Under the isolation plane, a total of 125 TFP seismic isolation bearings had been positioned beneath every major gravity column and under each nook of the shear wall cores. A global constructing structural analysis model turned into constructed using the commercial structural software program ETABS (CSI, 2011).

2. AtilaZekioglu, HuseyinDarama:

These authors describes the performance-based seismic design of the Sabiha Gocken1 International Airport (SGIA) Terminal Building (with one basement) in Istanbul, Turkey utilising seismic-isolation concept with triple-friction-pendulum gadgets with an area over a 160,000 rectangular meters and 252 seismic friction pendulum isolators.

3. Takao Nishizawa;

The author stats choice of retrofitting strategies of constructing with 6 floors, 1 basement, 1 penthouse & unfold foundation 1 basement as its investigations and diagnoses performed

found out that the primary constructing become lacking in seismic overall performance. For the seismically isolated memories, laminated rubber isolators containing a lead plug, rolling supports, and lead dampers were represented via a bilinear model and incorporated right into a single spring.

4. HuseyinDarama, AtilaZekioglu, Simon Rees, Chas Pope and Rory McGowan:
These authors describes the overall performance-based totally seismic layout of the building with single storey the irregularity of a building brought about the decision to apply Friction Pendulum (FP) kind isolators. These are taken into consideration to have higher structural overall performance in comparison to alternatives due to higher damping and decrease base shear forces, less difficult connection detailing on the isolation aircraft, and inherent self-centring behaviour.

5. Koji Tsuchimoto, Yoshikazu Kitagawa, Kazuo Yoshida, Yozo Shinozaki, Ichiro Nagashima, Yoichi Saui, Hiroyasu Komatsu, Takahide Kobayashi:
These authors introduces an instance of using base isolation system combining variable oil dampers with the conventional passive base isolation system. The machine became advanced to enhance habitability via decreasing acceleration in the course of small and medium-sized earthquakes. Subsequently, the effects of a time records response analysis inside the event of an earthquake is provided, and the effectiveness of the gadget in lowering acceleration is indicated. Finally, the tracking system, which serves as a fail-safe system is explained. The seismic isolation system for this building includes rubber bearings and oil dampers. The rubber bearings are fabricated from laminated natural rubber that possesses the linear restitution force properties and skinny steel plates. All electricity absorption at the seismic isolation tale is completed with the aid of the oil dampers.

6. C. Giarlelis, C. Kostikas, E. Lamprinou, M Dalakiouridou:
Their paper describes isolation system behaviour for building with the substructure consists of 9 floors housing mechanical plant rooms, parking and garage areas. At the parking areas, slabs are inclined to allow visitors drift. Access to those areas is provided by unbiased round ramps supported by way of an internal and an outside circular wall. It is tested dynamic reaction spectrum aiming to: (a) verify the fundamental length (b) Calculate maximum displacements (c) check for uplift. Analysis became accomplished thru the use of code ETABS with fps type isolator.

7. Stefano Sorace and Gloria Terenzi, Analysis:
In this paper they used double friction pendulum (DFP) sliders had been adopted as keeping apart gadgets. A general of 59 elements had been included, 57 of which on pinnacle of the basement columns.

**MODELLING AND METHODS**

This section present details of building taken for the comparison and modelling criteria in e tabs.

Here, 6 types of building analysed with LRB and FPS systems.

1. G+4 with 2 storied basement with 0.75 aspect ratio (G+4_2_0.75)
2. G+4 with 2 storied basement with 1 aspect ratio. (G+4_2_1)
3. G+4 with 2 storied basement with 1.25 aspect ratio(G+4_2_1.25)

Where, aspect ratio = total height of building to total width of building ratio.

The summarise data about building geometry is given below.

Grade of concrete = 25 $N/mm^2$

Yield strength of steel = 415 $N/mm^2$

Floor load = 3 $kN/m^2$

Slab thickness = 200 mm

Wall thickness = 200 mm

Floor height = 4 m

Bay width = 4 m

Size of beam = (300 X 450) $mm^2$ for G+4 building with 2 storied basement.

Size of column = (450 X 450) $mm^2$ for G+4 building with 2 storied basement.

The link property for the both type of isolator systems are derived and input the same in e tabs for analysis. Following are the linear and nonlinear property of isolators.

As we know the hysteretic loop for the behaviour of this systems gives,

1. Effective stiffness ($K_{eff}$),
2. Effective damping ($C_b$),
3. Post yield stiffness ratio ($Y_r$),
4. Yield strength ($F_y$)
5. Effective vertical stiffness ($K_v$).

Following are the link property data in terms of linearity and non-linearity for the G+4 building with 2 storied basement with aspect ratio 1.25, for LRB installation at middle level of the basement stories, bottom(foundation) level

**Figure 3: Etabs Modelling**

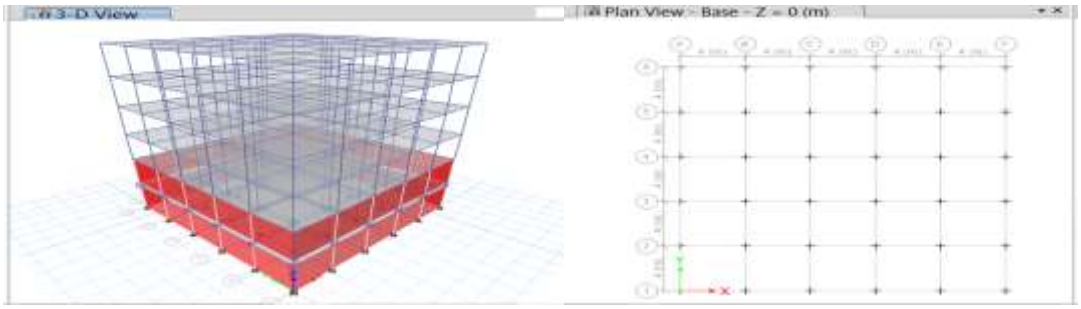

**Table 1: G+4_2 type building sets configuration**

| Description | Values |
|---|---|
| **Total height of building** | 24mm |
| **Plan dimension** | 32mX32m |
| **Story Height** | 4 m |
| **Bay Width in X-Direction** | 4 m |
| **Bay Width in Y-Direction** | 4 m |
| **Column Size** | 0.450 m X 0.450 m |
| **Beam Size** | 0.300 m X 0.450 m |
| **Slab Thickness** | 200 mm |
| **Wall Thickness** | 200 mm |
| **Characteristic Strength of Concrete** | 25 $N/mm^2$ |
| **Live Load on Typical Story** | 3 $kN/m^2$ |
| **Type of Soil –IS 1893:2002** | Hard |
| **Importance Factor** | 1 |
| **Seismic Zone – IS 1893:2002** | V (Z = 0.36) |
| **Response Reduction Factor** | 5 |

**Table2: Link Property Data for LRB with 1.25 Aspect ratio**

| Location of LRB | Building type | Average load | Effective stiffness | Effective damping | Yield strength | Post yield stiffness ratio | Vertical stiffness |
|---|---|---|---|---|---|---|---|
| | | kN | $K_{eff}$(kN/m) | $C_b$ (kN-s/m) | $F_y$(kN) | $Y_r$ | $K_v$ |
| **MIDDLE** | G+4_2 | 679.192 | 1431.99 | 180.06 | 28.54 | 0.12 | 6154027 |
| **GROUND** | G+4_2 | 505.6 | 1460.08 | 169.11 | 28.36 | 0.1 | 5497678 |
| **BOTTOM** | G+4_2 | 852.7 | 1148.19 | 185.18 | 28.27 | 0.11 | 8273885 |

**RESULT AND ANALYSIS**

The results on comparison of LRB and FPS is given below for all type of structures.

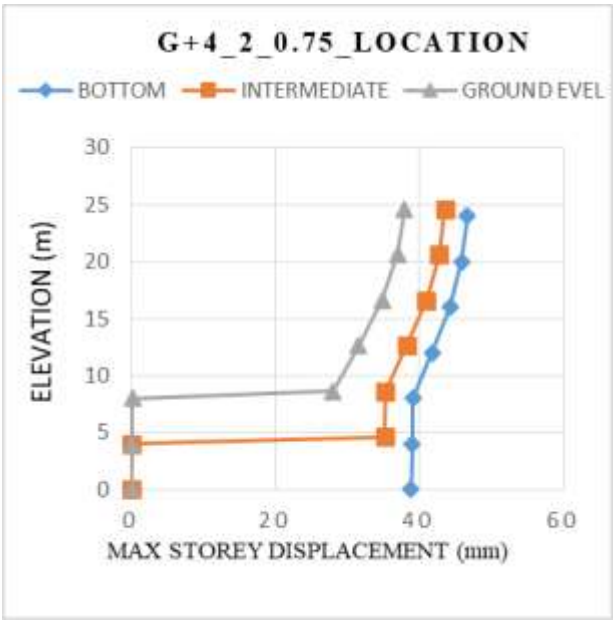


**Figure 4(a)**

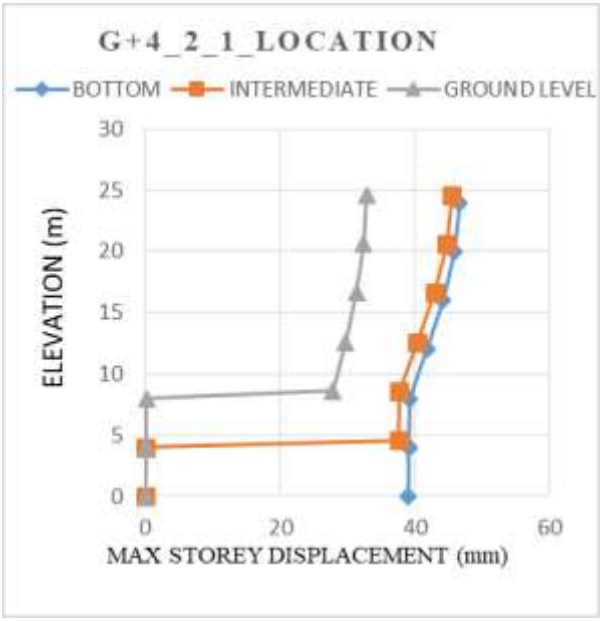


**Figure 4(b)**

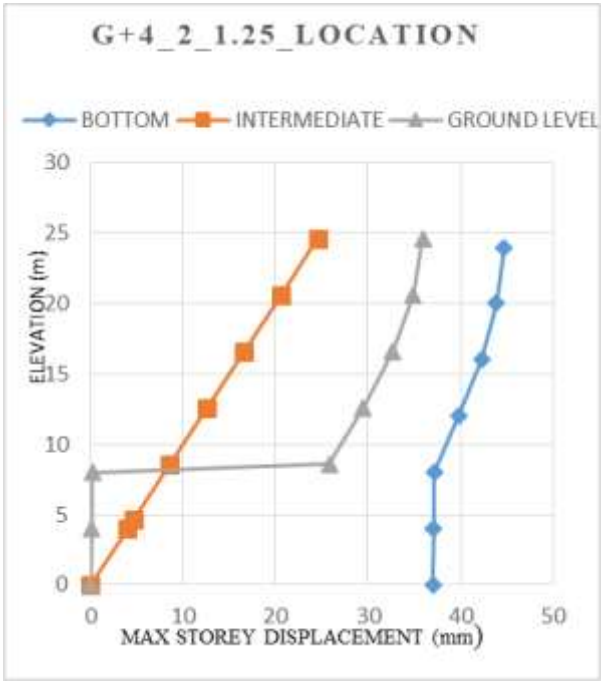


**Figure 4(c)**

**Figure 4 (a), (b), (c): Comparison of Storey displacement in G+4_2 type building**

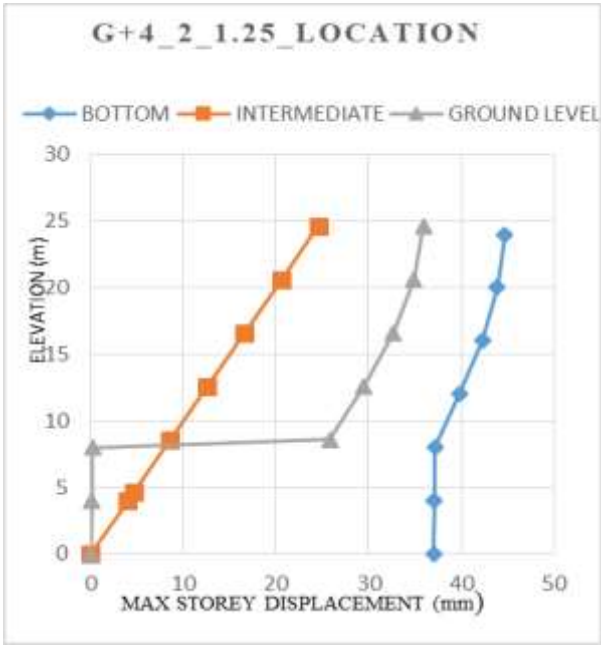


**Figure 5(a)**

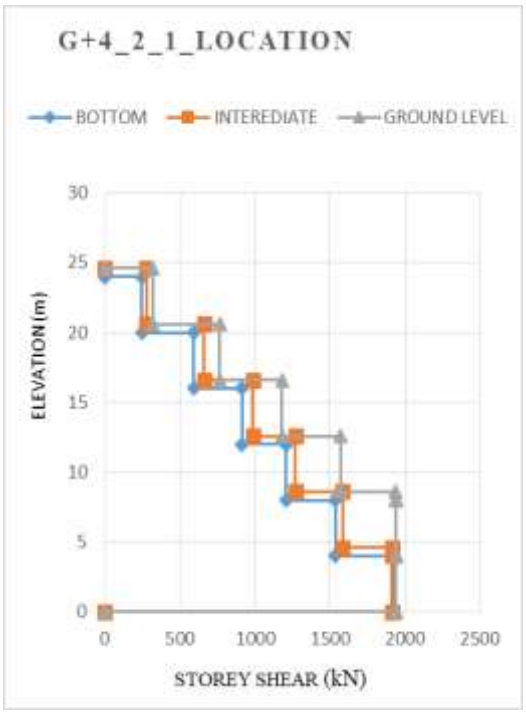


**Figure 5(b)**

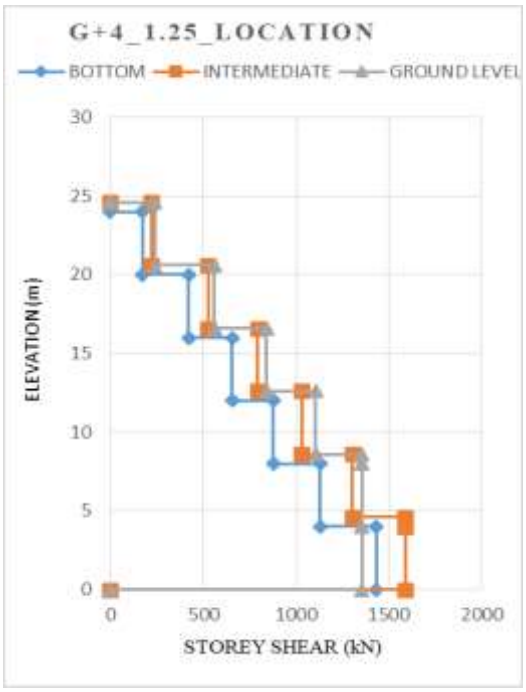


**Figure 5(c)**

**Figure 5 (a), (b), (c): Comparison of Storey shear in G+4_2 type buildings**

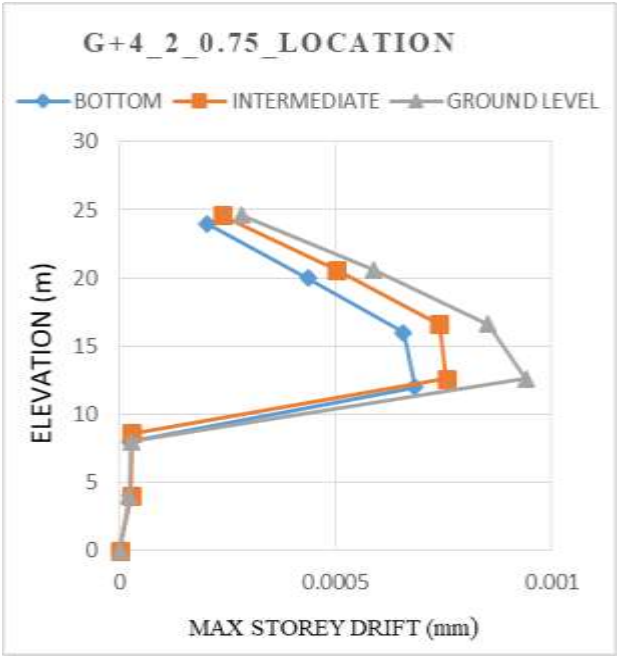


**Figure: 6(a)**

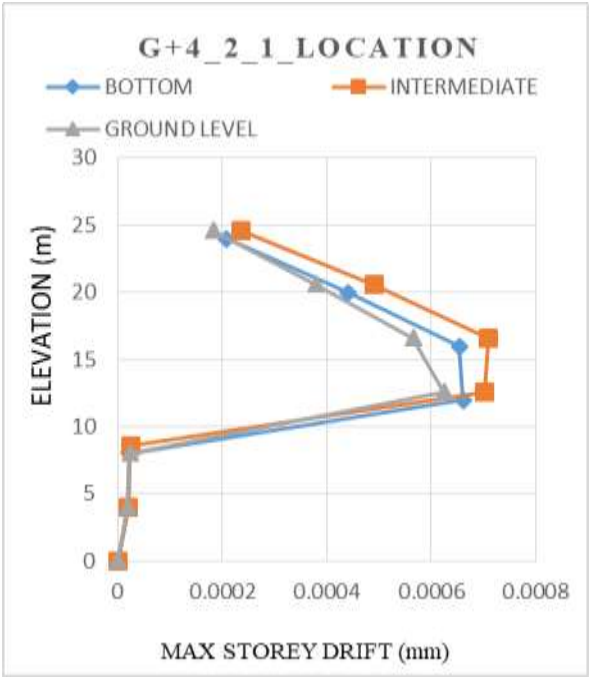


**Figure: 6(b)**

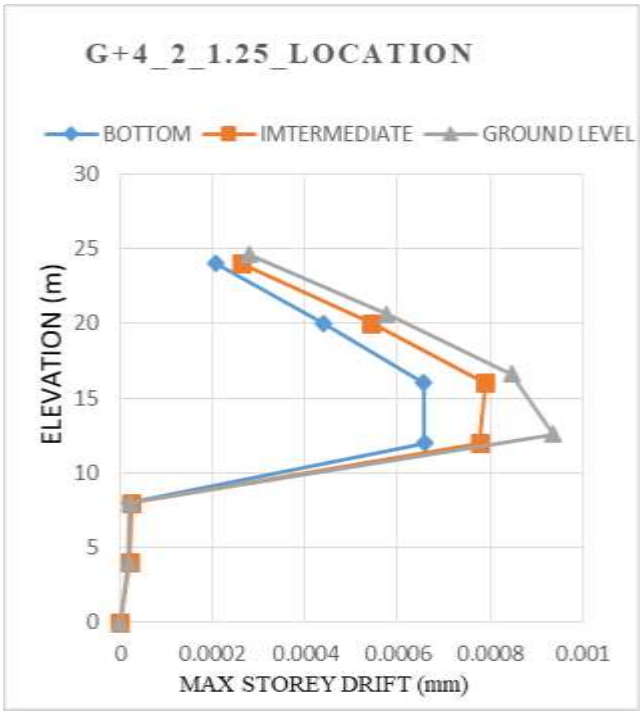


**Figure 6(c)**

**Figure 6 (a), (b), (c): Comparison of Storey driftt in G+4_2 type buildings**

**Table: 2 longitudinal steel provided in frame structure in G+4_2 type building**

| **G+4_2** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Longitudinal steel ($mm^2$)** | | | | | | | | |
| **0.75 (aspect ratio)** | | | 1 (aspect ratio) | | | 1.25 (aspect ratio) | | |
| **Column 5** **(0.9dl + 1.5 RSEQ)** | | | Column 4 (0.9dl + 1.5 RSEQ) | | | Column 3 (0.9DL+1. 5 RSEQ) | | |
| **BOTTOM** | MIDDLE | GL | BOTTOM | MIDDLE | GL | BOTTOM | MIDDLE | GL |
| **1812** | 1938 | 2032 | 1738 | 1766 | 1649 | 1828 | 2115 | 1720 |

## CONCLUSION

For the location study, LRB installation with ground level is acquired better results in terms of displacements. However, LRB at the bottom level is given minimize the value of drifts to compare to ground level and middle of the basement stories. In terms of designing, steel requirements met lesser value, if LRB is positioned at ground level.

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