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# Dynamic Soil Structure Interaction Behaviour of Asymmetric 3D Building Frames with Isolated Footing

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## ABSTRACT

In the fashionable design process, building frames are widely established at their bases. In any case, in all actuality, adaptability of supportive medium permits some development of establishment. This causes a decrease in stiffness of the building frames and hence subsequently causes an increase in natural periods and hence causes an alteration in the overall system. These effects can be seen in isolated footing building frames. In the present work, the response on building frames under seismic forces with isolated footings are incorporated with soil flexibility. The 3D analysis was carried out in SAP2000 V14 software. In the analysis, the soil is modeled as a spring with 6 DOF and its stiffness varies with the type of soil adopted with the following properties of soil such as dynamic shear modulus, poisons ratio etc. Impact of number of parameters, for example, number of stories, number of bays, diverse soil conditions and traverse to stature proportion and ground storey tallness is considered in present review. The analysis is carried out for bare frame in Seismic Zone-V with and without accounting for soil flexibility. From the analysis it is observed that the natural period, base shear, lateral displacement of the structure increases with the increase in number of storey, number of bays.

**Keywords:** Isolated Footings, soil-structure interaction, Modified Winkler Model.

## 1. INTRODUCTION

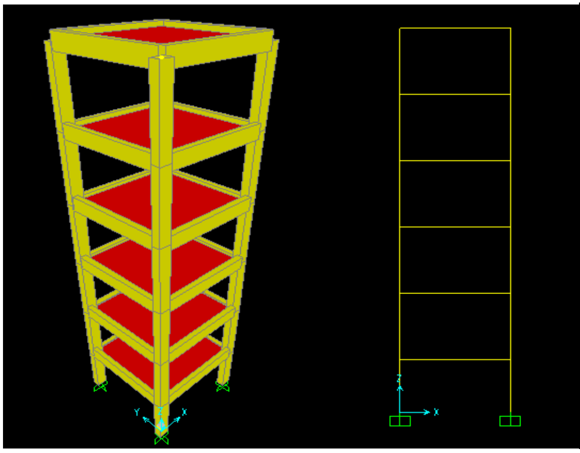
Dynamic soil-structure association manages the cooperation of the establishment and the soil at the point when subjected to dynamic stacking. Dynamic stacking alludes to loads shifting with time, e.g. quake, loads from pivoting hardware and so forth. The cooperation between a structure and its encompassing soil under unique stacking has turned into an imperative issue because of the expanding frame and development of huge and vital structures. For the most part building's base is thought to be encountering an indistinguishable movement from that of the free field ground movement which would be valid if the base was inflexible. In soils this is not the situation, so the motion in the base field is not the same as that of free field. The base movement involves several rocking components such as vertical, horizontal and transitional components. In this manner, the movement experienced at the base could be more noteworthy or, on the other hand weaker than that of the free field. In the seismic frame, the soil structure collaboration is ignored in ordinary buildings however the dynamic response of the structure is evaluated with fixed based response. During analysis, the soil undergoes deformations during seismic loading which imposes to the foundation. If the motion of the structure is altered, a question will arise, how the response of does the structure is modified by the supporting soil. This cooperation between the soil and the structure is called Soil-Structure Interaction (SSI). Number of researchers have analysed and presented their results for fundamental natural frequency, base shear, lateral deflection etc. Koushik Bhattacharya et al (2004) analysed the soil structure interaction of low rise buildings with raft foundation and proved that the impact of soil adaptability on horizontal characteristic period alongside the seismic base shear of the building is articulated with diminishing hardness of soil. Chandrasekhar et al (2005), analyzed multi-storey buildings with raft foundations resting on soft, medium and stiff soil. The result showed that the natural period decreases with the increasing plan dimension due to the increased stiffness of the base. Sharada Bai et al (2006), studied the effects of soil-structure –interaction in computation of lateral natural period and seismic base shear of building frames.

The horizontal regular time frame and the seismic base shear of the building frames considering and without considering the soil adaptability is contrasted with assess the soil structure association in building frames. Annigeri et al (2007), concentrated the impact of soil adaptability minor departure from the basic regular time frame and lateral displacement which greatly affect the performance of the building. Time periods and displacements are more in case of structure with flexible base when compared to rigid base structure. Halkude et al (2014), analysed the response on reinforced concrete frames with raft footing with soil structure interaction. He compared Winkler approach and elastic continuum approach and proved that elastic continuum approach is effective method. Somasekharaiah at al, (2015) analyzed 2x4 bay 4 storey RC frame plan with isolated footing supported on medium soil in different zones subjected to normal and seismic loads. The results showed that as storey increases, lateral displacement, frequency, storey drift also increases.

## 2. MODELING AND ANALYSIS METHODS

In the present review, Super structure of the building frame as 3D space edge is displayed utilizing SAP2000 V14 FEM auxiliary examination programming bundle. 3D space frame demonstrate as appeared in Figure 1 and 2 comprising of array of pillars and section components. Any torsion impacts are naturally considered in the model. The ground movements can be connected in 1, 2 or 3 bearings exclusively or all the while.

In the investigation, the quake load is connected independently along X and Y bearings. Two noded line components with six degrees of opportunity at every hub speak to bars and sections in every storey as appeared in Figure 1 also, Figure 2.



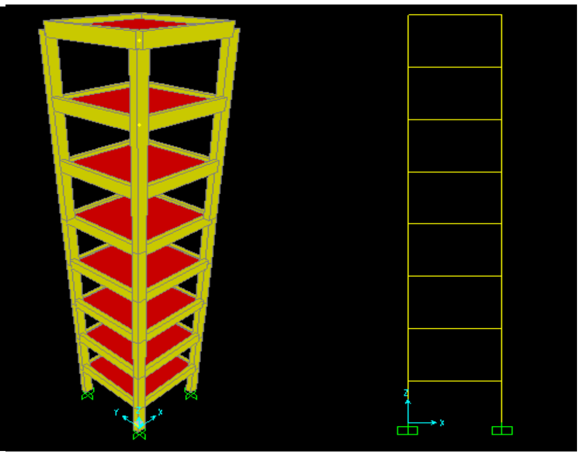


**Fig. 1: 1 bay 1 bay 6 Storey** **Fig. 2: 1 bay 1 bay 8 storey**

**Idealization of Soil Media**

The soil considered is sandy earth and is admired utilizing Adjusted Winkler Model

**Modeling and Analysis of soil as Modified Winkler Model**

This model proposed by George Gazetas (1991) varies from Winkler display in the angle that it considers 6 springs-3 translational and 3 rotational to represent progression of soil medium to certain extent(for change over Winkler model) and subsequently is alluded to as Adjusted Winkler Show in the present review. Beneath the focal point of gravity of the establishment, three translational springs along commonly opposite worldwide tomahawks together with three rotational springs about these commonly opposite worldwide tomahawks are appointed as appeared in figure 3 to reenact the impact of soil-adaptability.

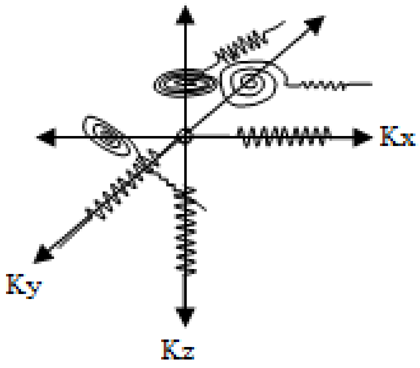



**Fig. 3: Representational of plan for springs toward every hub to changed Winkler model.**

**Stiffness of Elastic springs**

The solidness of springs in each translational and rotational course are computed as proposed by Gazetas and suggested by ATC-40. Figure 4 demonstrates the strategy for appointing the proportional spring firmness esteems in the product.

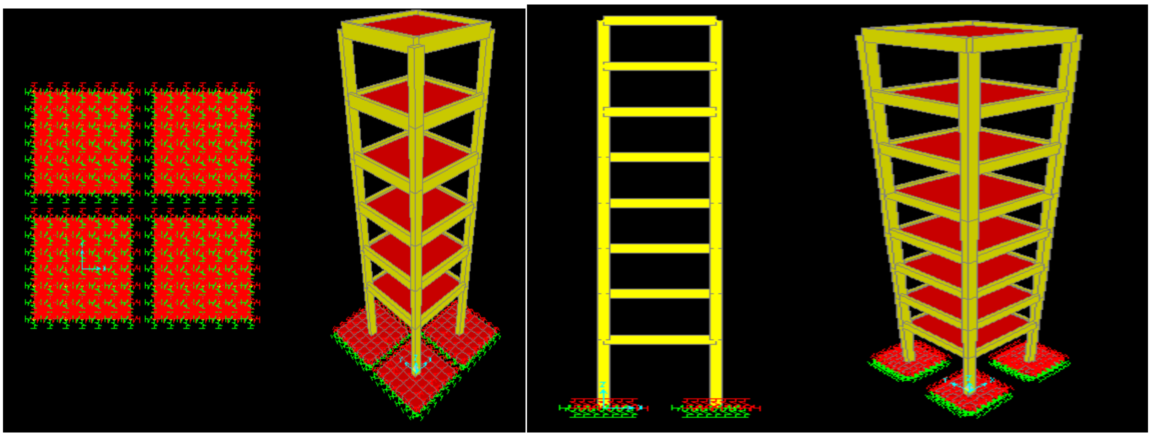


**Fig. 4: 1 bay 1 bay 6 storey, HR-1.5 Fig. 5: 1 bay 1 bay 8 storey**
**Typical schematic representation of springs in Modified Winkler Model adopted for Isolated Foundation**

The Detached Establishment is discretized with the end goal that the viewpoint proportion of every component is equivalent to 1.0 as appeared in Figure 5 and the soil framework is romanticized by six springs at every hub ( three interpretations and three revolutions ). The territory of balance affecting every hub for computing firmness of the springs at that hub is shown in Figure 6.

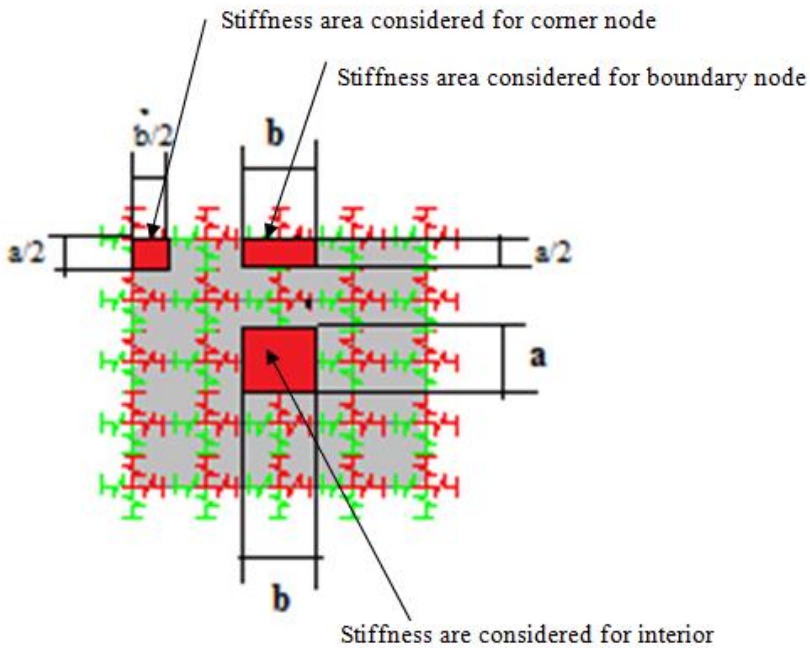



**Fig. 6: Schematic representation of a portion of discretized Isolated foundation in Modified Winkler Model**

**Interaction Analysis (IA)**

3D frame establishment soil cooperation units are discretized and displayed as portrayed in SAP2000 Version-14 Basic FEM Programming bundle, soil being spoken to utilizing Changed Winkler demonstrate. Dynamic examination (Response Spectrum Method) is completed is termed as Interaction analysis as per [6].

**Analysis Without Interaction**

The customary examination of the 3Dimentional edge has been completed by considering the section closes as settled (without considering types of soil) with all the basic info by unaltering the parameters as that of connection investigation and is alluded to as Non-Interaction analysis in the present review.

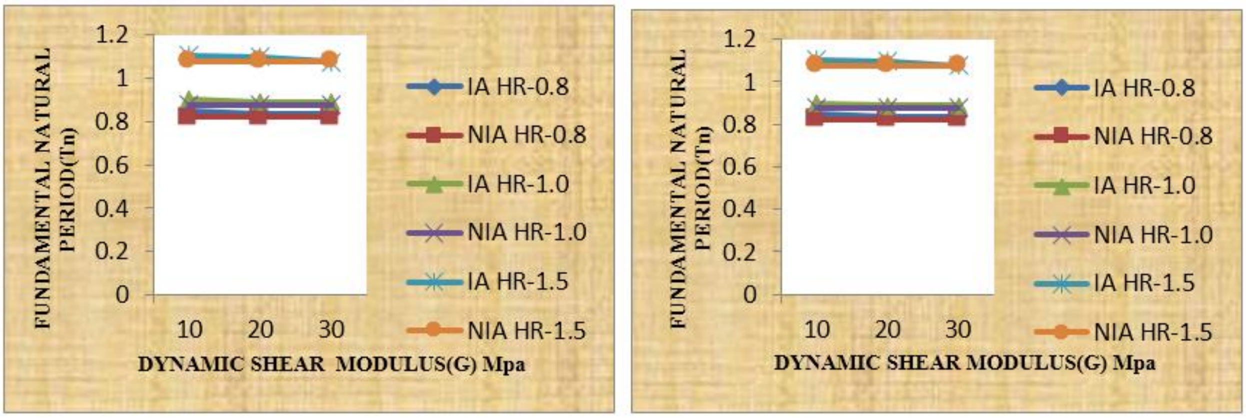
**Combination of load Intensity**

For both the analysis as mentioned in 2.2 and 2.3 examination, The following load combination has been used as per [6] -2002 are: 1.5(DL+LL), 1.2(DL+LL±$EL_x$), 1.2(DL+IL±$EL_y$), 1.5(DL±$EL_x$), 1.5(DL±$EL_y$), 0.9DL±1.5$EL_x$, 0.9DL±1.5$EL_y$.

**COMMENTS**

The dynamic examination finished with and without relationship as per the system for examination depicted. The outcomes are talked about in detail with viz Fundamental Natural Period, Seismic Base Shear, Maximum parallel Displacement, Axial powers in the base storey segments, Bending moment or 1 bay 1 bay 6 & 8 storey's structures with Isolated establishment.

### (a) Fundamental Natural Period

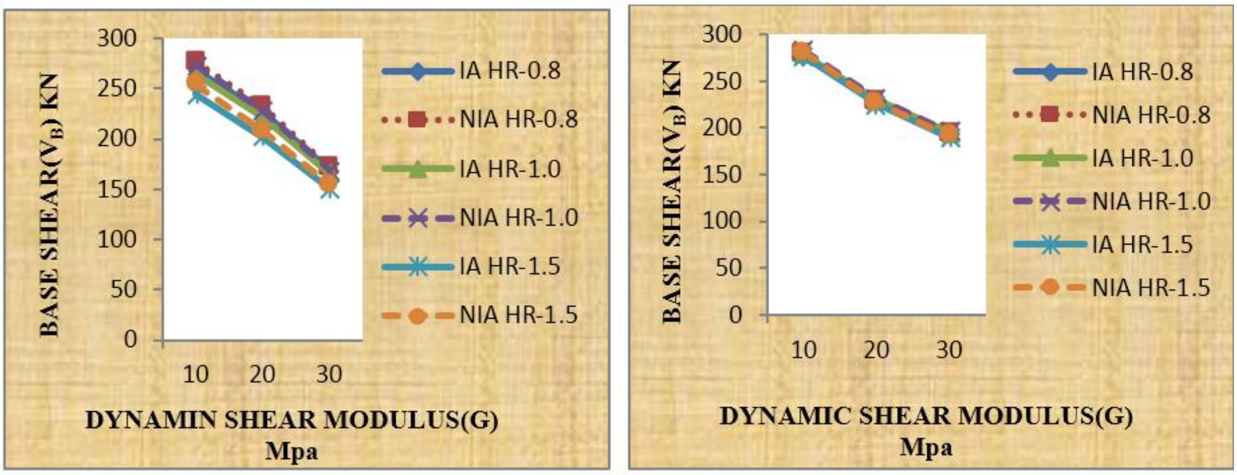



**(a) 1x1 6 Storey** **(b) 1x1 8 Storey**

**Fig.7: (a) & (b) Fundamental Natural Period (Tn) Vs Dynamic Shear Modulus (G).**

Figure 7 (a) &(b) speaks to variety of Fundamental Natural Period with dynamic shear modulus of soil for various soil frames for 1 bay 1 bay 6 storey and 1 bay 1 bay 8 storey. It is watched that Fundamental Natural Period is greatest for delicate soil and reductions with increment in the shear modulus of soil. Considering regarding hardened (Type-I) soil, the Fundamental Natural Period demonstrates most extreme addition from delicate (Type-III) soil, which is as per the following:- 1 bay 1 bay 6 storey – 1.21% ; 1 bay 1 bay 8 storey– 1.14%

### (b) Base Shear

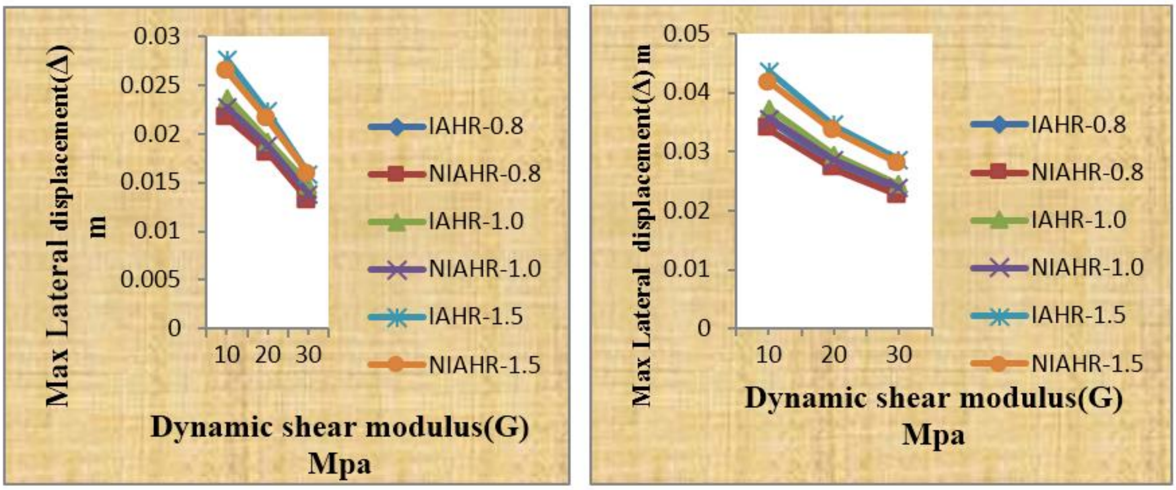



**(a) 1x1 bay 6 Storey** **(b) 1x1 bay 8 Storey**

**Fig. 8: (a) & (b) Variation of Base Shear ($V_B$) Vs Dynamic Shear Modulus (G).**

Figure 8 (a) and (b) Shows the change in Base Shear with dynamic shear modulus of soil for 1 bay 1 bay 6 storey and 1 bay 1 bay 8 storey. Base Shear is most extreme for delicate soil and reductions with increment in the shear modulus of soil. Rate diminish with increment in shear modulus i.e. from delicate soil to solid soil is 1 bay 1 bay 6 storey – 59% (HR-0.8); 1 bay 1 bay 8 storey - 43% (HR-0.8). Along these lines, it is watched that 8 storey structures demonstrate higher variety in Base Shear than 6 storey**.**

**(c) Lateral Displacement**



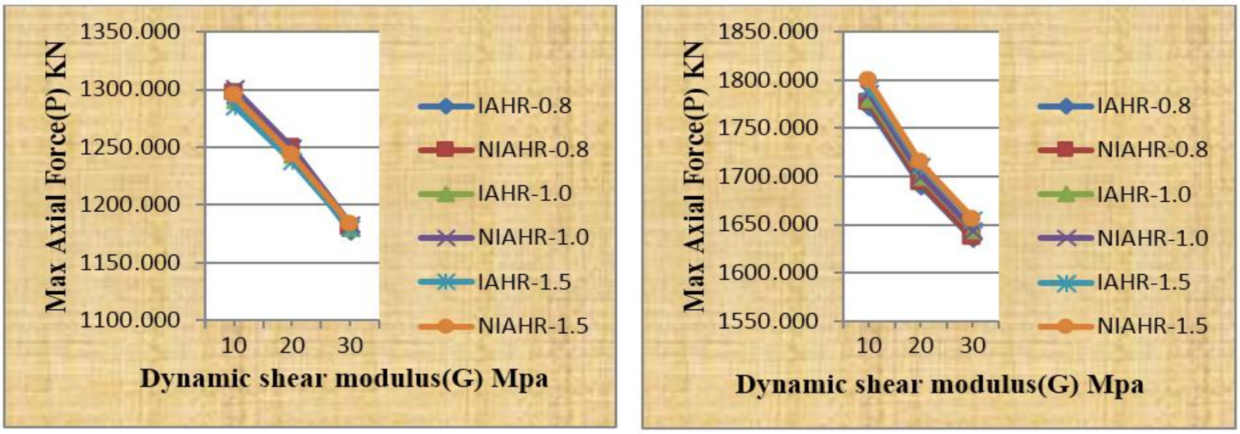

**(a) 1x1 6Storey** **(b) 1x1 bay 8Storey**

**Fig. 9: (a) & (b) Variation of Lateral Displacement (Δ) Vs Dynamic Shear Modulus (G).**

Figure 9 (a) and (b) speaks to variety of dynamic shear modulus and Lateral Displacements of soil for 1 bay 1 bay 6 storey and 1 bay 1 bay 8 storey. It is watched that Lateral Displacement (Δ) which is greatest for delicate soil, diminishes with increment in the shear modulus of soil. For 1 bay 1 bay 2 storey indicates increment in Lateral Displacements from solid to medium soil is 3%, Whereas, for 1 bay 1 bay 8 storey , the expansion in Lateral Displacements from firm to medium soil is 24%.

**(d) Axial Force**

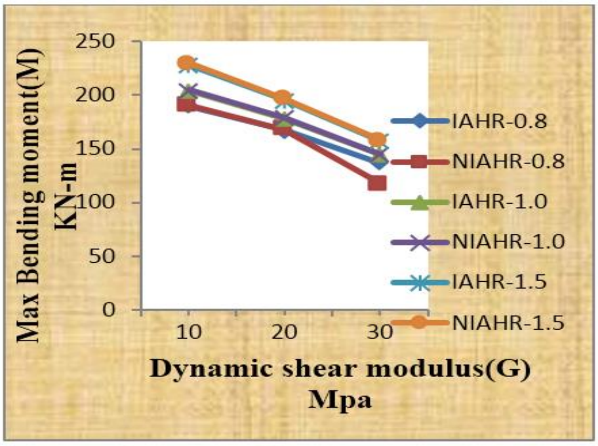
Figure 10 (an) and (b) demonstrates the variety of axial force with dynamic shear modulus of soil for 1 bay 1 bay 6 storey and 1 bay 1 bay 8 storey. From fig. 9 it has been seen that axial force in section diminishes with increment in modulus of shear of soil for 1 bay 1 bay 6 storey and 1 bay 1 bay 8 storey. Axial force diminishes from delicate (Type-III) soil to solid (Type-I) soil for 1 bay 1 bay 6 and 8 storey by 9.4 % and 8.2% individually.



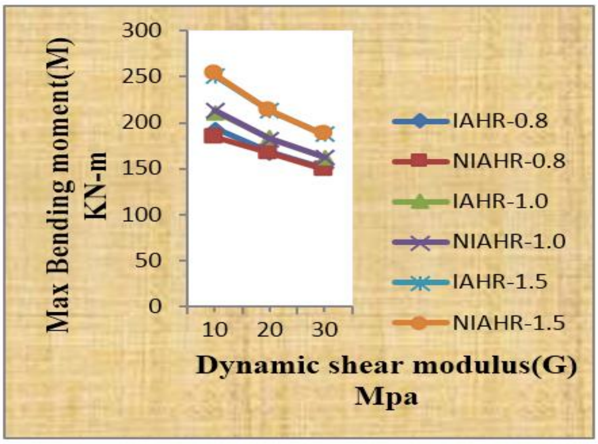

**(a) 1x1 bay 6Storey** **(b) 1x1 bay 8Storey**

**Fig. 10: (a) & (b) Variation of Axial Force (P) Vs Dynamic Shear Modulus (G).**

**(e) Bending Moment**




(a) 1x1 6Storey




(b) 1x1 8Storey

**Fig. 11: (a) & (b) Represents the variation of Bending Moment (M) Vs Dynamic Shear Modulus (G).**

Figure 11 (a) and (b) demonstrates that Bending Moment diminishes with increment in shear modulus of soil for 1 bay 1 bay 6 storey and 1 bay 1 bay 8 storey. By and large the connection impacts as far as bowing minute in bar is to expand the qualities with sort of soil, i.e. with abatement in shear modulus. For 1 bay 1 bay 6 storey the Bending Moment diminishes around 12% from delicate Type-III soil to medium Type-II soil and 22% medium Type-II soil to hard Type-I. However, if there should be an occurrence of 1 bay 1 bay 8 storey, the Bending Moment decreases about 15% & 12% from soft Type-III soil to Medium Type-II soil and Medium Type-II soil to stiff Type-I soil respectively.

## 3. CONCLUSIONS

The conclusions that can be drawn from the analysis are

- The essential normal time of a specific structure increments as the modulus of shear soil reductions. Further, soil turns out to be more adaptable.
- For any given course, the base shear esteems for a specific structure increments as the relative firmness calculate estimation of the soil increments due to soil changes from sort I to sort III.
- The uprooting values along any of the flat bearings diminishes as the relative solidness element of soil increments.
- Axial forces in base story sections change with the relative firmness variable of soil contingent upon the position of the segment (inside or outside) independent of the bearing.
- For 8 story structure, the bending moment esteem in considered bars increments with the lessening in modulus of shear in the soil.

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