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Performance of Flat Slab Structure Using Pushover Analysis

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Abstract : *Performance Based Seismic Engineering is the modern approach to earthquake resistant design. It is a limit-state based design approach extended to cover complex range of issues faced by structural engineers. Flat slabs are becoming popular and gaining importance as they are economical as compared to beam-column connections in conventional slab. Many existing flat slabs may not have been designed for seismic forces so it is important to study their response under seismic conditions and to evaluate seismic retrofit schemes. In this paper we have discussed the results obtained by performing push over analysis on flat slabs by using most common software SAP2000. A (G+7) frame having 5 bays is considered for analysis. It is observed that the performance point of flat slab is more as compared to conventional building.*
Keywords: *Capacity, Demand, Performance point, ATC 40, FEMA-356.*

I. Introduction

Recent earthquakes in which many concrete structures have been severely damaged or collapsed, have indicated the need for evaluating the seismic adequacy of existing buildings. About 60% of the land area of our country is susceptible to damaging levels of seismic hazard. We can't avoid future earthquakes, but preparedness and safe building construction practices can certainly reduce the extent of damage and loss. In order to strengthen and resist the buildings for future earthquakes, some procedures have to be adopted. One of the procedures is the static pushover analysis which is becoming a popular tool for seismic performance evaluation of existing and new structures. By conducting this push over analysis, we can know the weak zones in the structure and then we will decide whether the particular part is retrofitted or rehabilitated according to the requirement. In this paper we are performing the push over analysis on flat slabs by using most common software SAP2000.Many existing flat slab buildings may not have been designed for seismic forces. Hence it is important to study their response under seismic conditions and to evaluate seismic retrofit schemes. But when compared to beam-column connections, flat slabs are becoming popular and gaining importance as they are economical.

The development of performance based codes for the design or rehabilitation of buildings in seismic active areas show that an inelastic procedure commonly referred to as the pushover analysis is a viable method to assess damage vulnerability of buildings. Basically, a pushover analysis is a series of incremental static analysis carried out to develop a capacity curve for the building. Based on the capacity curve, a target displacement which is an estimate of the displacement that the design earthquake will produce on the building is determined. The extent of damage experienced by the structure at this target displacement is considered representative of the damage experienced by the building when subjected to design level ground shaking. Many methods were presented to apply the nonlinear static pushover (NSP) to structures. These methods can be listed as: (1) the capacity spectrum method (CSM) (ATC) [1], (2) the displacement coefficient method (DCM) (FEMA-356) [2]. The approach has been developed by many researchers [3, 4, 5] with minor variation in computation procedure. Since the behavior of reinforced concrete structures may be highly inelastic under seismic loads, the global inelastic performance of RC structures will be dominated by plastic yielding effects and consequently the accuracy of the pushover analysis will be influenced by the ability of the analytical models to capture these effects.

II. System Development

2.1 pushover methodology

A pushover analysis is performed by subjecting a structure to a monotonically increasing pattern of lateral loads, representing the inertial forces which would be experienced by the structure when subjected to ground shaking. Under incrementally increasing loads various structural elements may yield sequentially.

Consequently, at each event, the structure experiences a loss in stiffness. Using a pushover analysis, a characteristic non linear force displacement relationship can be determined. A generalized force-displacement characteristic of a non-degrading frame element (or hinge Properties) is shown in Figure 1.

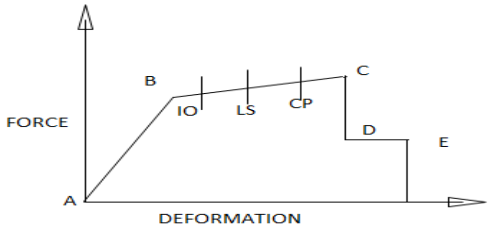


Figure 1: Typical force deformation curve

Point A corresponds to unloaded condition and point B represents yielding of the element. The ordinate at C corresponds to nominal strength and abscissa at C corresponds to the deformation at which significant strength degradation begins. The drop from C to D represents the initial failure of the element and resistance to lateral loads beyond point C is usually unreliable. The residual resistance from D to E allows the frame elements to sustain gravity loads. Beyond point E, the maximum deformation capacity, gravity load can no longer be sustained.

2.2 capacity

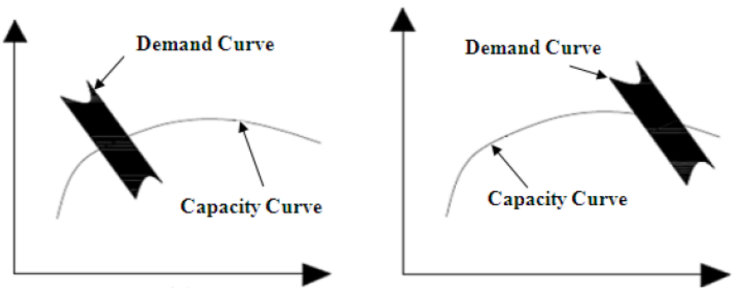
The overall capacity of a structure depends on the strength and deformation capacities of the individual components of the structure. A Pushover analysis procedure uses a series of sequential elastic analysis, superimposed to approximate a force –displacement capacity diagram of the overall structure. The mathematical model of the structure is modified to account for reduced resistance of yielding components. A lateral force distribution is again applied until a predetermined limit is reached. Pushover capacity curves approximate how structure behaves after exceeding the elastic limits.

2.3 demand (displacement)

Ground motions during an earthquake produce complex horizontal displacement patterns in structure that may vary with time. Tracking this motion at every time step to determine structural design requirements is judged impractical. For nonlinear method it is easier and more direct to use a set of lateral displacement as a design condition for a given structure and ground motion, the displacement is an estimate of the maximum expected response of the building during ground motion.

2.4 performance point:

The intersection of the capacity spectrum with the appropriate demand spectrum in the capacity spectrum method (the displacement at the performance point is equivalent to the target displacement in the coefficient method). Typical seismic demand Vs. Capacity is shown in following figures.



(a) (b)

Figure 1: Typical seismic demand capacity curve

(a) Safe design (b) Unsafe design

III. Performance Analysis

The G+7 conventional building and G+7 Flat slab building are considered in this study. The material Properties are M25 Grade concrete, Fe 500 steel for the yield strength of the longitudinal and transverse reinforcement. The model of flat slab structure and the conventional building are shown in the following figures.

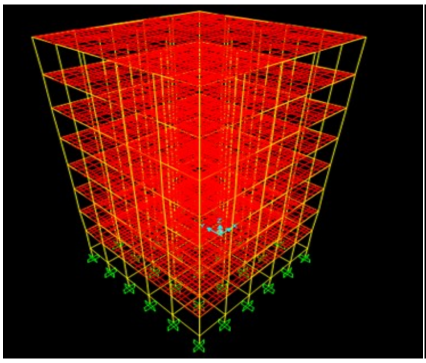


Figure no.2 Flat slab model

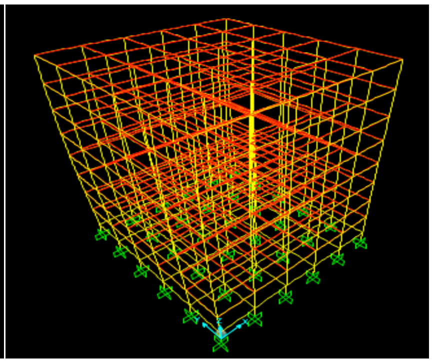


Figure no. 3 Conventional building model

The typical floor height is 3 m and the details of beams and columns are shown in table1.

Table no. 01: Details of beams and columns

Type Of Structural System	Slab(mm)	Column (mm)	Beam(mm)
Conventional Building	120	350 X 350	230 x 380
Flat Slab Building	150	350 X 350	

The general finite element package SAP 2000 has been used for the analyses. A three-dimensional model of each structure has been created to undertake the non-linear analysis.

IV. Results And Discussion

The resulting pushover curve for the conventional building and for flat slab building is shown in fig. A 2m displacement is given to the structures, the base shear of the conventional structure was 32831.6 KN, and for flat slab structure was 26406.5 KN. Thus the base shear on flat slab is less as compared to the conventional building because the flexibility of flat slab is more than conventional building.

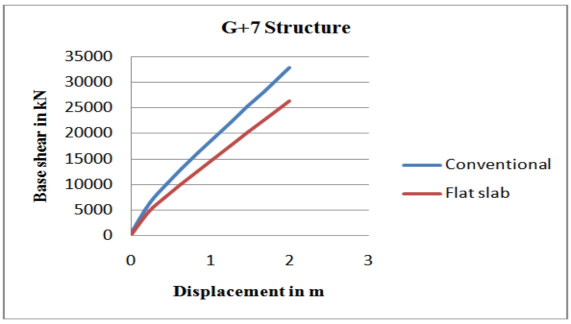


Figure no. 4 Variation of a Base shear v/s Dispalcement

The following figures showing the performance point for flat slab and for conventional building. The performance point for flat slab is 0.437m and for conventional building it is 0.362m thus the performance point for flat slab is more as compare to conventional structure due to they are more flexible than conventional structure.

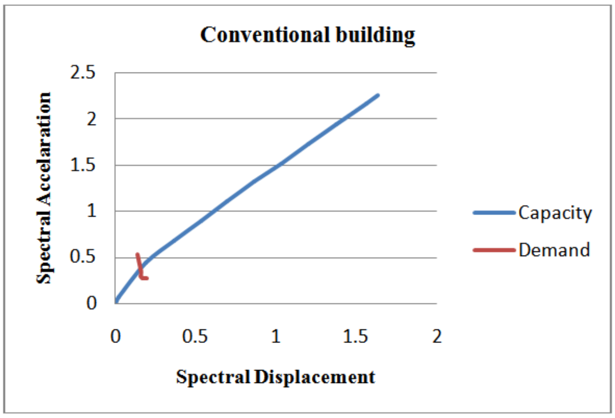


Figure no. 5 Capacity-Demand curve for G+7 Conventional Building

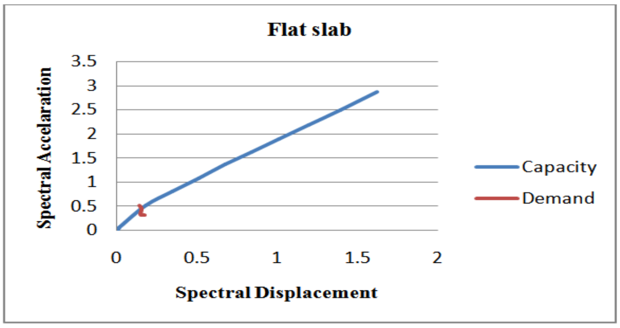


Figure no. 5 Capacity-Demand curve for G+7 Conventional Building

V. CONCLUSION

1. The pushover analysis is a relatively simple way to explore the non linear behavior of buildings.
2. Base shear of conventional RCC building is more than the flat slab building.
3. The performance point of flat slab is more than the conventional structure due to its flexibility.
4. The behavior of properly detailed conventional building is adequate as intersection of the demand and capacity curves.
5. The results obtained in terms of demand, capacity gave an insight into real behavior of the structure.

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