Comparison of Behaviour of Multistoried Buildings with Floating Column and Plan Irregularities in Different Seismic Zones

Deepti Hazari[1] Mrs. Shraddha Sharma[2]
[1,2]Department of Civil Engineering
[1,2]Bhilai Institute of Technology, Durg, Chhattisgarh, India

Abstract— In developing country like India where urbanization is at a faster rate, buildings with floating column has been introduced. The main focus is on the importance of structure with floating column under different plan irregularities in construction particularly in G+4 structures. It clears the idea of floating column, its scope and benefits. Meanwhile it depicts the comparison of structures with regular and irregular shapes under different positioning of floating column in zone II and zone V using STAAD Pro software. Experiments results show comparison with displacement, base shear and cost effectiveness of all the structures. This will help us to find the various analytical properties of the structure and we may also have a very systematic and economical design for the structure.

Key words: Floating Column, STAAD. Pro Software

I. INTRODUCTION

A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which ends (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it. Such columns where the load was considered as point load. Floating columns are usually adopted above the ground storey level. So that maximum space is made available in the ground floor which is essentially required in apartments, mall or other commercial buildings where parking is a major problem.

Looking ahead, of course, one will continue to make buildings interesting rather than monotonous. However, this need not be done at the cost of poor behavior and earthquake safety of buildings.

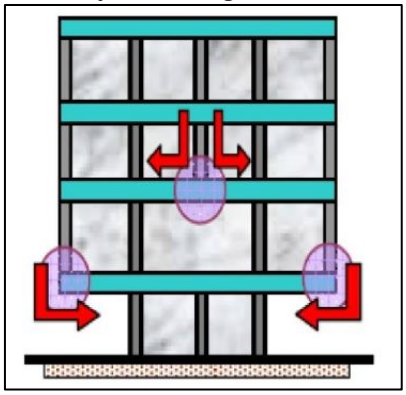

Fig. 1: Hanging or floating columns

When irregular features such as floating columns are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features, so the normal regular and irregular structures are compared with floating column structures with different position.

II. BUILDING DESCRIPTION

The study is carried out on a regular and irregular shaped building with floating column and normal column. The layout of the building is shown in the figure. The building considered is a multistory building having G+4 structures.

A. Regular G+4 Normal Structure

It is a five storey building with one roof. The length and width of each floor is 12m and 8m. The total height of structure is 21m.This model has been analysed by creating fixed support on ground storey, by assigning dead load, live load and earthquake load with accidental load in zone II and zone V.

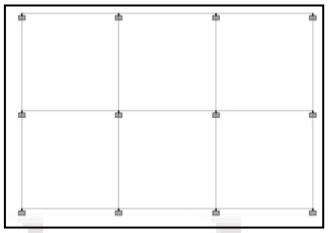

Fig. 2: A regular building with normal column

B. Regular G+4 Floating Column Structure

It is a five storey building with one roof. The length and width of each floor is 12m and 8m. The total height of structure is 21m.This model has been analysed by creating fixed support on ground storey, by assigning dead load, live load and earthquake load with accidental load in zone II and zone V.

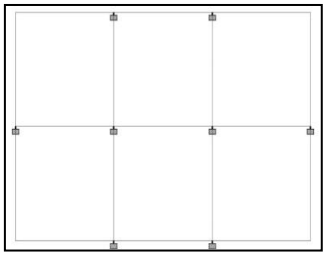

Fig. 3: A regular building with floating column in corners

C. Regular G+4 Floating Column Structure

It is a five storey building with one roof. The length and width of each floor is 12m and 8m.

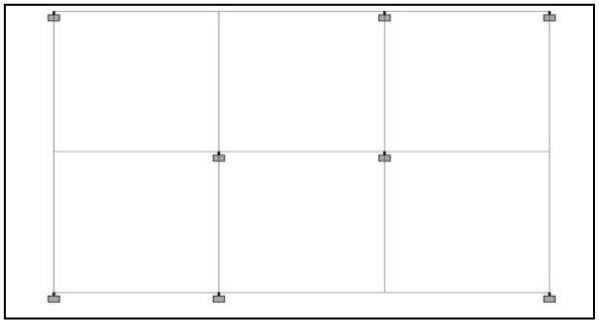

Fig. 4: A regular building with floating column in middle

The total height of structure is 21m.This model has been analysed by creating fixed support on ground storey, by assigning dead load, live load and earthquake load with accidental load in zone II and zone V with different position of floating column.

D. Irregular G+4 Normal Structure

It is a five storey building with one roof. The length and width of each floor is 20m and 16m. The total height of structure is 21m.This model has been analyzed by creating fixed support on ground storey, by assigning dead load, live load and earthquake load with accidental load in zone II and zone V.

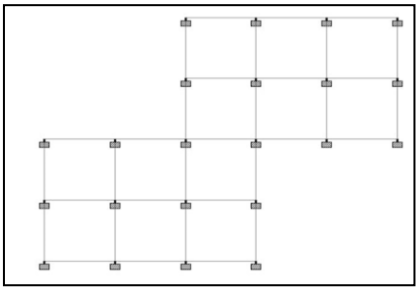

Fig. 5: An irregular building with normal column

E. Irregular G+4 Floating Column Structure

It is a five storey building with one roof. The length and width of each floor is 20m and 16m. The total height of structure is 21m.This model has been analyzed by creating fixed support on ground storey, by assigning dead load, live load and earthquake load with accidental load in zone II and zone V.

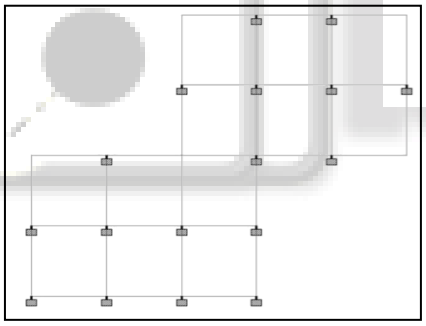

Fig. 6: A regular building with floating column in corners

F. Irregular G+4 Floating Column Structure

It is a five storey building with one roof. The length and width of each floor is 20m and 16m. The total height of structure is 21m.This model has been analyzed by creating fixed support on ground storey, by assigning dead load, live load and earthquake load with accidental load in zone II and zone V with different position of floating column.

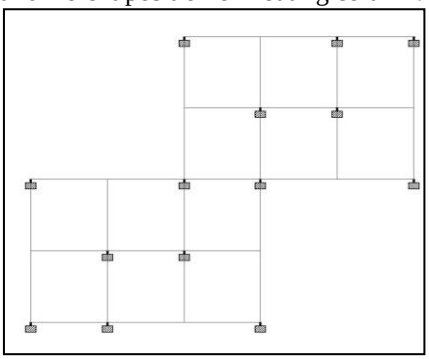

Fig. 7: A Regular Building with Floating Column in Middle

III. LOAD COMBINATION

For design of reinforced concrete structures, the load combination 1.5(DL + LL+EQ) in X and Z directions are used.

IV. ANALYSIS OF STRUCTURE

Displacement Calculations have been shown in Table- and Table-

Displacement in X direction						
Building with zones	Ground Plinth	1st Floor	2nd Floor	3rd floor	4th floor	Roof
R II	0.10	0.23	0.42	0.59	0.72	0.79
R V	0.35	0.83	1.51	2.12	2.59	2.86
IR zone II	0.10	0.23	0.43	0.60	0.73	0.81
IR zone V	0.36	0.84	1.54	2.16	2.64	2.92
FR zone II	0.14	0.29	0.50	0.69	0.84	0.94
FR zone V	0.51	1.05	1.80	2.48	3.03	3.38
NFR zone II	0.17	0.34	0.58	0.80	0.97	1.08
NFR zone V	0.54	1.06	1.79	2.44	2.97	3.29
NFIR zone II	0.15	0.28	0.48	0.65	0.79	0.87
NFIR zone V	0.21	1.09	1.71	2.34	2.83	3.12
FIR zone II	0.14	0.30	0.52	0.73	0.89	0.98
FIR zone V	0.52	1.13	1.93	2.66	3.25	3.63

Table 1: Displacement in X direction

Displacement in Z direction						
Building with zones	Ground Plinth	1st Floor	2nd Floor	3rd floor	4th floor	Roof
R II	0.04	0.12	0.22	0.32	0.39	0.44
R V	0.16	0.44	0.80	1.14	1.42	1.59
IR zone II	0.04	0.12	0.22	0.31	0.38	0.42
IR zone V	0.15	0.43	0.78	1.11	1.37	1.53
FR zone II	0.07	0.18	0.32	0.44	0.55	0.63
FR zone V	0.25	0.65	1.13	1.59	1.98	2.28
NFR zone II	0.08	0.20	0.34	0.47	0.57	0.64
NFR zone V	0.23	0.56	0.95	1.32	1.61	1.81
NFIR zone II	0.06	0.14	0.24	0.34	0.41	0.47
NFIR zone V	0.21	0.51	0.88	1.22	1.49	1.67
FIR zone II	0.07	0.16	0.30	0.42	0.52	0.59
FIR zone V	0.28	0.72	1.21	1.66	2.04	2.32

Table 2: Displacement in Z direction

V. RESULTS

A. Displacement Results

1) Results using Displacement Graphs in Z Direction

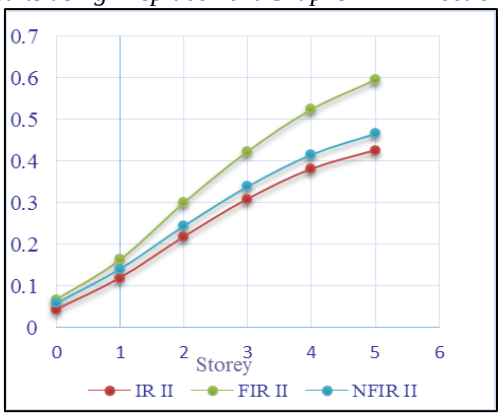

Fig. 8: Graph showing displacement of all irregular buildings of zone II in Z directions.

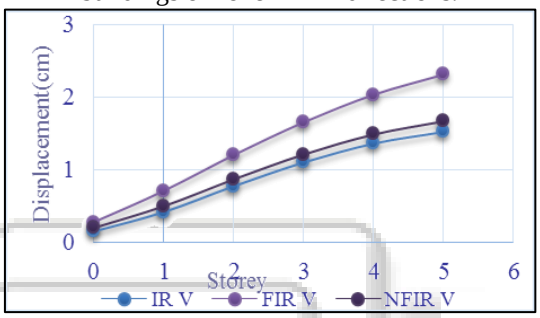

Fig. 9: Graph showing displacement of all irregular buildings of zone V in Z directions

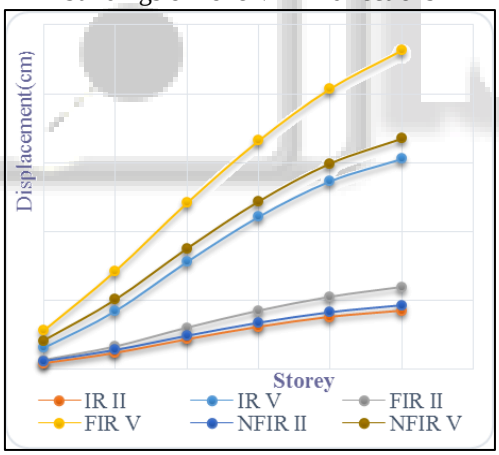

Fig. 10: Graph showing displacement of all irregular buildings in Z directions

It is concluded that the displacement of building increases from lower zones to higher zones, because the magnitude of intensity will be more for higher zones. From graph it is clear that irregular buildings of zone II shows less displacement than buildings of zone V irrespective of floating columns. Also buildings with floating columns at the ends or corners should not be made. High rise irregular buildings in zone V is strictly not advisable in zone V unless preventive measures are not taken. Displacement is maximum when the floating column is placed at the .corners thus it must be strictly avoided.

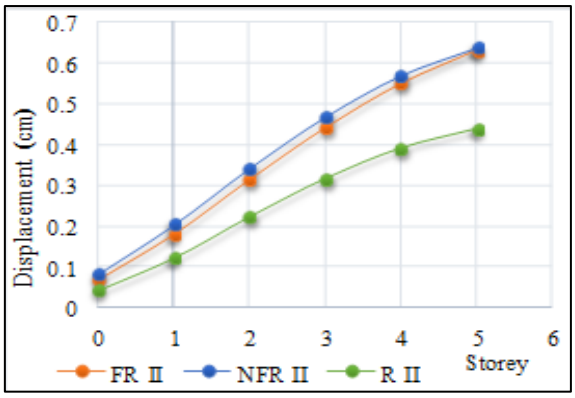

Fig. 11: Graph showing displacement of all regular buildings of zone II

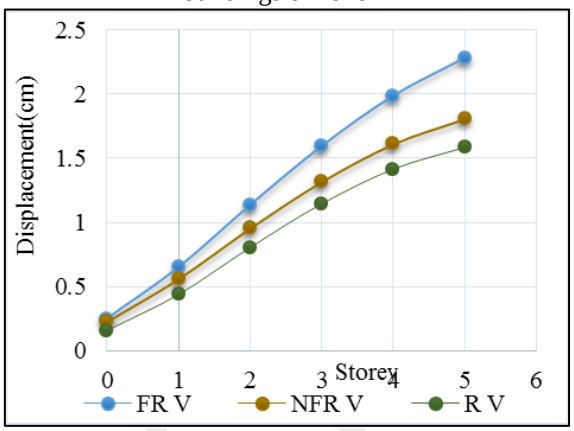

Fig. 12: Graph showing displacement of all regular buildings of zone II

Providing four floating columns in the ground floor leads the instability of structure and thus regular structure with floating column shows maximum displacement in zone II. However in zone V structure with floating column in the corners shows maximum displacement

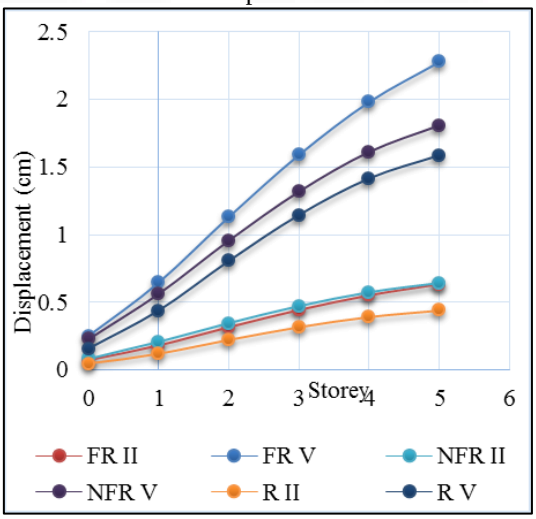

Fig. 13: Graph showing displacement of all regular buildings in Z directions

Structure with floating column in the corners in zone V gives maximum displacement. But floating column in the center of outer faces shows slightly more displacement than floating columns at the ends. This is due to the change in number of columns removed and position of columns.

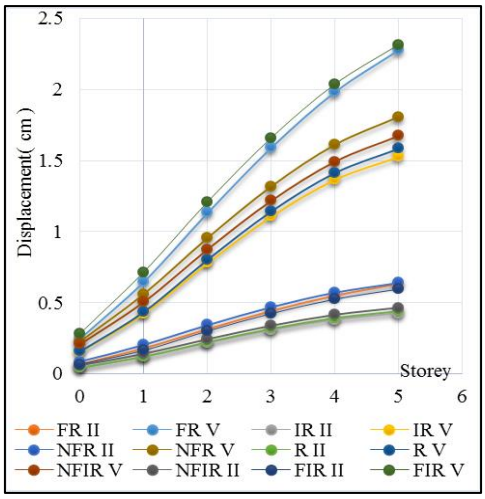

Fig. 14: Graph showing displacement of all the frames in Z direction

The maximum displacement is shown by FIR V and the minimum y zone II. Hence regular building is safe whether made in zone II and zone V. But regular building with floating column at the ends shows variations depending upon the number of columns removed and positing of columns. By varying the position of floating column in ground floor in zone II the structure shows high displacement than the irregular structures.

2) Results using displacement graphs in X direction

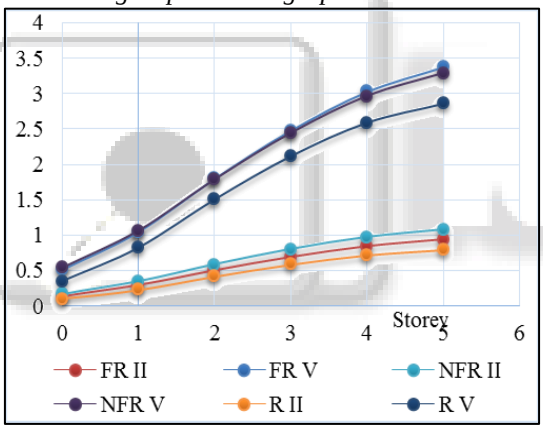

Fig. 15: Graph showing displacement of all the regular frames in X direction

Zone V structures shows more than twice higher displacement than zone II. Also regular structures with floating column in middle of outer faces show more displacement due to removal of no. of columns. Thus more mass is required structure lacks in maintain static initial condition

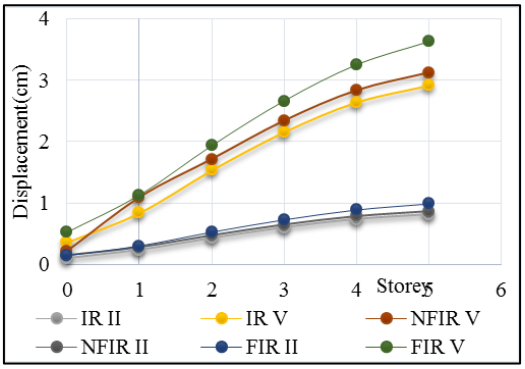

Fig. 16: Graph showing displacement of all the irregular frames in X direction

Structure with irregular shapes gives more displacement. Floating column in the outer corner shows maximum displacement and leads the structure highly unsafe in zone V. Also zone II irregular structure varies 0.08 cm from the floating column suture in same zone. Thus with proper retrofitting, designing irregular structures with floating column can be made for aesthetic view

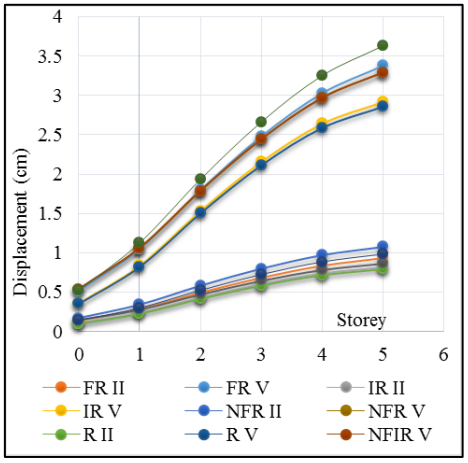

Fig. 17: Graph showing displacement of all the frames in X direction

Building with regular zones with normal columns shows least displacement in zone II. The maximum displacement is shown by zone V irregular building having floating column at the ends. Thus this irregular structure with floating column in zone V should not be preferred. Also all buildings of zone II have less displacement than zone V. Irregular buildings with floating column at the outer face in middle shows less displacement than regular floating column at the corners. Hence floating column at the ends of outer faces must not be preferred in both regular and irregular cases

B. Base Shear Results

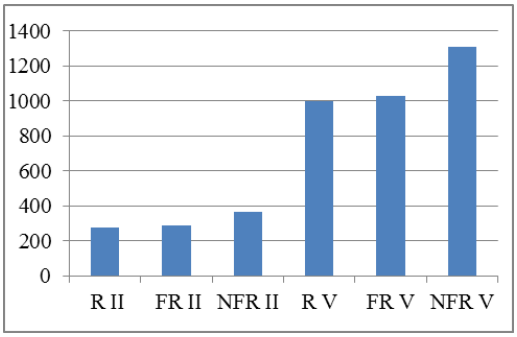

Fig. 18: Graph showing base shear all the regular structures

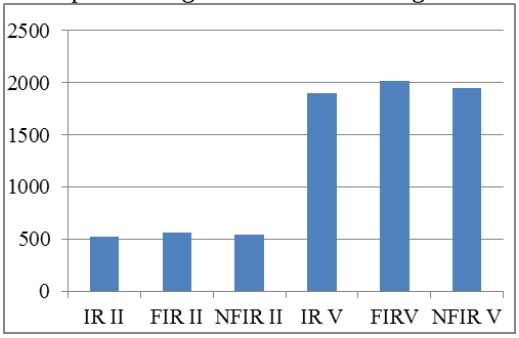

Fig. 19: Graph showing base shear all the irregular structures

Graph showing base shear of regular structures with floating and non-floating structure. With varying zone and column size, the base shear increases. Also by changing the position of column the base shear changes. By providing four inner columns as floating column the structure shows high base shear.

Structures in zone V shows high seismic shear at the base. Floating column provided at the corners shows high base shear as compared to the columns provided in the center in the ground floor

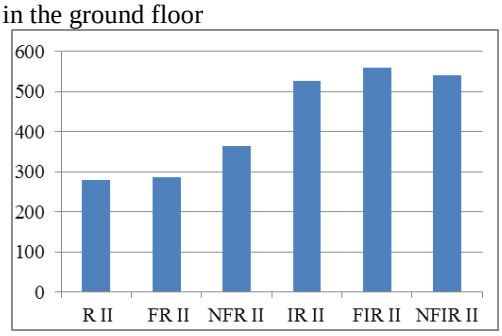

Fig. 20: Graph showing base shear of all the structures of zone II

It is clear that all the irregular structures with different positioning of floating column shows high base shear than all the regular structures taken.

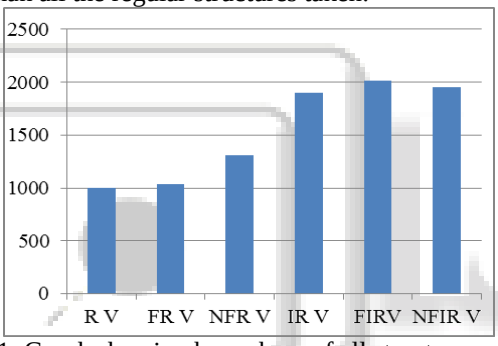

Fig. 21: Graph showing base shear of all structures of zone V.

Irregular buildings with floating column at the corners shows the highest base shear due to its structural configuration and dimension of columns and weight of the structure.

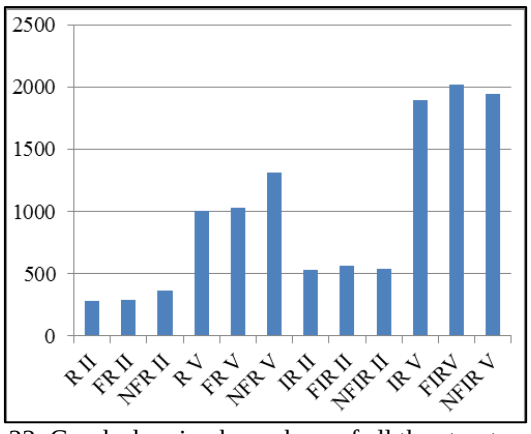

Fig. 22: Graph showing base shear of all the structures of zone II and zone V

From all the structures it is clear that zone II structures shows less base shear as compared to zone V structures. Also floating column irregular structures show high base shear in both the zones II and V. Zone V structures shows more than two times of base shear than zone II Thus higher the seismic zone of the structure, more will be its base shear. Regular structures are safer for construction in both zones

VI. Conclusion

1) In the framed structure with no floating columns the nodal displacements is minimum with uniform distribution of stresses at all beams and columns. As a result it is most economical. Storey displacement increases due to presence of floating column.
2) Base shear increases with increase in irregularity of structures with floating column. Irregular building with floating column at the corners shows maximum base shear in zone II and zone V
3) The G+4 regular structures are safe in both the zones II and zone Regular structure with floating column in the centre shows maximum displacement in Z direction due to presence of many floating columns in the ground floor and mass irregularity in zone II.
4) Irregular structure with floating column at the corners show maximum displacement in both X and Z direction of zones V
5) Regular structure shows least displacement in both X and Z direction in their respective zones. Structures in X direction show much higher displacement than in Z direction.
6) Displacement increases with increase in height of structure. Displacement of zone V structures is more than 2.5 times of zone II structures.
7) Structure with floating column in zone II can be made both regular and irregular shape and are economical. Regular structures with normal column are the most economical in both the zones II and V.
8) The section required by the structure with floating column is more. The floating column is subjected to maximum base shear is compared to the structure with normal column

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