Analysis of Multi-Storey RC Frame Irregular Step-Up Structure with Fixed Base and Using Base-Isolation Damper Support in High Seismic Zone

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Abstract

Development is a non-stop process it is seen that nowadays the development has reached to a new level. The development doesn't mean construction in the sphere of civil engineering or architecture but the way has changed a lot of definition of development itself. The serviceability, durability, safety, innovation in design etc. are lot more things to be concerned. The design approach has now gone so far in the field of advancement in the use of software analysis. Since, the complex structures and multi-storey structures cannot be solved with ease manually the help of more detailed and dynamic analysis has helped to solve such structures. Nowadays demand for aesthetic, modernization and urban growth cause to design complex structures with lots of plan and vertical irregularities. The structures in seismic zone are also the part of complex design so it is important to study more into the detail to go more into the concept and derive more calculative and conservative solutions.

Keywords – *Base-isolation damper, Frame structure, Irregularity, Response Spectrum Method, Seismic Zone.*

Introduction

Earthquakes are the most vulnerable and biggest threat which causes severe damages. Earthquakes can strike at any time and any place. When it comes to its true form it never spares anything and ruins everything around it. However, this is not the end the life comes with no break it has to go on and on. The engineers are at their best to find every possible study, apply all science and theory to deal more successfully to all these uncertainties.

The use base isolation has come as an emerging solution to solve the problems faced by the structure in seismic zone. The engineers to be used in building design nowadays accept the base-isolation. The method is popular in the field of research to be used in broader manner in various parts of the structure to be employed to get desirable results. The techniques are widely used because of its successful results. Therefore, more work is done in the field research.

Literature Survey

The past study had helped us to collect very effective information regarding the failure reasons. It has helped us to gather more informative results which can be dealt further to arrive at more better solutions at per present scenario. As with time the design and innovation in the construction advance there is a need to find more appropriate solutions as per present need.

A. Sharma and B. Bhadra (2018)- The comparison of the irregular and regular structure has been made. Effects of various irregularities on the seismic performance and response on structure by RSA and THA is done for mass, stiffness and vertical geometry. The study tells that the stiffness irregular structure experience lesser base shear and large inter-storey while the mass irregular buildings frames experiences larger base-shear than similar regular building frames. Storey shear value maximizes for the 1st storey and decreases to minimum for in all the top stories.

S. C. Dubule and D. Ainchwar (2018)- G+13 storey structure is analysed by RSM method in seismic zone III by using the STAAD Pro V8i software. The study is done on the vertically irregular structure by RSA and carried out the ductility-based design using IS 13920. Mass irregular structure undergoes larger base shear than similarly constructed regular structure.

K. Shah and P. Vyas (2017)- The study explains about determination of storey displacement, base shear, storey drift and storey shear of G+14 building coming in zone V using the software ETABS. The irregularities taken are mass and geometric irregularity. Results gives that for symmetrical infill wall structure minimum and maximum storey displacement for vertically irregular structure.

R. Vinod and N. R. Joshuva (2018)- The analysis of vertical geometrical irregularity in the form of set-backs are used in tall height buildings. The no. of bays and bay width on the behaviour of building under seismic zone with set-back as irregularity using modal analysis approach in SAP 2000 using response spectrum. It conveys that increasing no. of bays and bay width increases the time period of the structure.

H. Bansal and Gagandeep (2012)- The design of RC frame building using RSA and THA method. The building is vertically irregular, the ductility design on three types of irregularities mass, stiffness and vertical geometry is considered. Mass irregular building undergoes larger base shear compared to similar regular building while the stiffness irregular building experience less base shear and large inter storey drift.

S. M. Hussain and Dr. S. K. Tengli (2018)- The design of 14 storey building using 3-Dimensional model with ETABS using RSM method. To study the torsional behaviour on the asymmetrical model and resist the inelastic twist. Torsion causes increase in shear forces on the column and increase in displacement and drift values. Hence, it is preferable to use the special moment resisting frames.

K. S. Swathirani, G. B Murlidhara and N. B. S. Kumar (2015)- The study of different types of isolation systems on fixed base building is done. LRB with high values of damping is used for achieving optimum design using SAP 2000 software. The shear forces on columns are reduced and increases the time period values. It is seen rubber isolation with high damping values work well compared to other isolation stiffeners.

R. B. Ghodke and Dr. S.V. Admane (2015)- The design of moment resistance frame on 5-storey building with rubber isolation in SAP 2000 software is done. The study tells with the increase in height displacement values increases for fixed base but with the incorporation of base-isolation in the building the displacement values decreases with the height.

B. Balachandra and S. Abraham (2018)- In this a G+3 and G+20 height building analysis is done by time history analysis using ETABS 2015 and study of the behaviour of the building is done. Best method for earthquake resistance design. LRB is used for base-isolation. LRB reduces the base shear more in vertical irregularity. Time period of structure increases with the use of base-isolation technique, which reduces the lateral forces reaching to the structure.

Expected Outcomes and Need of the Study

The recent study and work done tells us about that a structure should be regular because a regular structure shows response. The presence of irregularity in a structure which may be plan or vertical irregularity which has ill effects on the performance and stability of the structure.

It is very important to study about the various aspects that affects the performance of the building, so that its performance can be improved. The irregularities in the structure beyond the specified limit will be responsible to non-performance of the structure. Since irregularity in structure is just a problem, it is not an end which can be solved with more experiences, vast study, more reliable conceptual analysis, approach to wisdom and further detailed study in up-coming years.

Problem Formulation and Objective

The structure is an Irregular G+7 RC Frame Multi-storey building. The structure is irregular along the height possess vertical irregularity. The structure is considered to be in high seismic Zone V with damping ratio (ξ) of 5%. The cases taken here is an irregular structure with step-up at storey-6 which is having fixed-base support is compared with the same irregular structure with step-up at storey-6 having base-isolation (LRB). The Dynamic analysis approach is used for the study of response of the structure and design by RSA (Response Spectrum Analysis).

The object of the study is to determine the behaviour of the irregular structure with step-up under the seismic load. The base isolation used in the structure to study the behaviour of structure containing irregularity.

The comparison made on the irregular structure behaviour having fixed and isolated base using rubber isolator.

To study the effect on the structure in the form of displacement, lateral loads, storey stiffness, storey shear, storey drift, modal load participation ratios, modal mass participation ratios.

The purpose here is to determine how base-isolation helps to overcome the effects of seismic ground excitation.

Result Analysis

The analyses performed on the structure having vertical structural irregularity are given. The results are shown here in graphical and tabulated format. Various results are put together for that useful conclusion can be obtained by comparison of the analysis data.

Table 1: Maximum Storey Displacement

Storey	Elevation	Fixed Base Support				Isolated Base Support			
		EQx		EQy		EQx		EQy	
		Dir-x	Dir-y	Dir-x	Dir-y	Dir-x	Dir-y	Dir-x	Dir-y
	(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
S-8	24	32.208	0.003	6.466	36.472	47.626	0.001	12.007	57.995
S-7	21	29.887	0.003	6.45	34.388	46.656	0.001	11.992	57.09
S-6	18	26.084	0.004	6.406	30.919	45.079	0.002	11.959	55.596
S-5	15	21.538	0.009	6.13	26.434	43.184	0.004	11.822	53.655
S-4	12	17.529	0.002	4.843	21.368	41.482	0.001	11.255	51.436
S-3	9	13.04	0.001	3.522	15.818	39.536	0.00042	10.661	48.957
S-2	6	8.274	0.0004	2.205	10.006	37.39	0.002	10.045	46.258
S-1	3	3.496	0.004	0.922	4.213	34.767	0.006	9.308	42.971
Base	0	0	0	0	0	28.962	0.102	7.689	35.48

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Table 2: Maximum Storey Stiffness

Storey	Elevation	Fixed Base Support				Isolated Base Support			
		EQx		EQy		EQx		EQy	
		Dir-x	Dir-y	Dir-x	Dir-y	Dir-x	Dir-y	Dir-x	Dir-y
	(m)	(kN/m)	(kN/m)	(kN/m)	(kN/m)	(kN/m)	(kN/m)	(kN/m)	(kN/m)
S-8	24	183450.81	0	0	193411	177546	0	0	186051
S-7	21	201329.24	0	0	209596	197453	0	0	204871
S-6	18	223268.75	0	0	221879	219893	0	0	217860
S-5	15	324434.44	0	0	325034	318353	0	0	318838
S-4	12	328667.52	0	0	327887	322778	0	0	321962
S-3	9	331563.19	0	0	331062	322082	0	0	321505
S-2	6	341106.45	0	0	340641	283947	0	0	283144
S-1	3	472333.65	0	0	472159	126420	0	0	121000
Base	0	0	0	0	0	0	0	0	0

Table 3: Maximum Storey Shear

Storey	Elevation	Fixed Base Support				Isolated Base Support			
		EQx		EQy		EQx		EQy	
		Dir-x	Dir-y	Dir-x	Dir-y	Dir-x	Dir-y	Dir-x	Dir-y
	(m)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)
S-8	24	-425.6603	0	0	-401	-172.04	0	0	-166.62
		-425.6603	0	0	-401	-172.04	0	0	-166.62
S-7	21	-765.8855	0	0	-721.66	-311.62	0	0	-302.09
		-765.8855	0	0	-721.66	-311.62	0	0	-302.09
S-6	18	-1017.381	0	0	-958.91	-417.48	0	0	-405.2
		-1017.381	0	0	-958.91	-417.48	0	0	-405.2
S-5	15	-1292.54	0	0	-1217.9	-538.99	0	0	-522.49
		-1292.54	0	0	-1217.9	-538.99	0	0	-522.49
S-4	12	-1474.037	0	0	-1388.8	-627.4	0	0	-607.83
		-1474.037	0	0	-1388.8	-627.4	0	0	-607.83
S-3	9	-1579.897	0	0	-1488.4	-691.84	0	0	-670.08
		-1579.897	0	0	-1488.4	-691.84	0	0	-670.08
S-2	6	-1631.362	0	0	-1536.9	-746.18	0	0	-722.64
		-1631.362	0	0	-1536.9	-746.18	0	0	-722.64
S-1	3	-1649.152	0	0	-1553.7	-820.02	0	0	-794.13
		-1649.152	0	0	-1553.7	-820.02	0	0	-794.13
Base	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0

Table 4: Modal Mass Participation Ratios

Case	Mode	Fixed Base Support				Isolated Base Support			
		Period	Sum	Sum	Sum	Period	Sum	Sum	Sum
		sec	UX	UY	UZ	sec	UX	UY	UZ
Modal	1	1.347	0	0.6106	0	3.357	0	0.8285	0
Modal	2	1.268	0.807	0.6106	0	3.237	0.9947	0.8285	0
Modal	3	1.055	0.807	0.8129	0	2.769	0.9947	0.9949	0
Modal	4	0.482	0.807	0.8885	0	0.644	0.999	0.9949	0
Modal	5	0.482	0.908	0.8885	0	0.643	0.999	0.9988	0
Modal	6	0.448	0.908	0.9089	0	0.575	0.999	0.999	0
Modal	7	0.276	0.9572	0.9089	0	0.353	0.999	0.9995	0
Modal	8	0.275	0.9572	0.9567	0	0.347	0.9997	0.9995	0
Modal	9	0.259	0.9572	0.9578	0	0.321	0.9997	0.9997	0
Modal	10	0.187	0.9759	0.9578	0	0.213	0.9998	0.9997	0
Modal	11	0.186	0.9759	0.9757	0	0.212	0.9998	0.9998	0
Modal	12	0.173	0.9759	0.9763	0	0.198	0.9998	0.9998	0
Modal	13	0.15	0.9759	0.9866	0	0.162	0.9999	0.9998	0
Modal	14	0.149	0.9882	0.9866	0	0.162	0.9999	0.9998	0
Modal	15	0.139	0.9882	0.9884	0	0.152	0.9999	0.9999	0
Modal	16	0.118	0.9964	0.9884	0	0.127	0.9999	0.9999	0
Modal	17	0.118	0.9964	0.9965	0	0.127	0.9999	0.9999	0
Modal	18	0.11	0.9964	0.9965	0	0.119	0.9999	0.9999	0
Modal	19	0.103	0.9985	0.9965	0	0.105	0.9999	0.9999	0
Modal	20	0.102	0.9985	0.9987	0	0.105	0.9999	0.9999	0

Conclusion

The main purpose here is to study the concept very into the detail and obtain the solutions derived from previous works done till the date now. To work forward more effectively using the more popular solutions which is generated so far. The objective here is to evaluate better solutions in the scope of topic of irregularity in the structures.
The very conclusion which are as follows:

1. The base isolated irregular structure has caused lesser lateral forces on the structures as compared to irregular structures with fixed support.
2. The maximum storey displacement is more in case of base-isolated irregular structures as compared to fixed base irregular structures.
3. Increased storey drift and displacement due to vertical irregularity as compared to same structure without irregularity.
4. Storey shear values highly increased in storey-6 (S-6) because of step-up in the structure.
5. Storey shear values is highly reduced with the help of isolated base support as compared to same irregular structure with fixed support.
6. Storey stiffness was maximum at S-1 storey, after that it increased up to storey S-3 after that it reduces up to the storey S-8.
7. Isolated base irregular structure with step-up has more time period values as compared to same structure with fixed base support.
8. Modal mass participation ratio is more for isolated structure than fixed base irregular structure.
9. Modal load participation ratio is more for isolated structure than fixed base irregular structure.

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