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Seismic Performance Evaluation of In-Plan Irregular R.C. Moment resisting Frame with Mid-Pier and Multi-layered shell element of Shear wall modelling- A Critical Review

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Abstract: The earthquake causes serious damage to property, life and multistoried building. Here ,all type of buildings built in an Indian standard & generally situated in earthquake prone areas as defined by IS 1893: 2002 should be designed for stresses, load & resulting out of earthquake. Various types of investigation techniques are available for examination of multi-story or tall structures which are Response spectrum method, Equivalent lateral force method, Time history method and code provision technique. Many authors tried to study analysis of multi-story building with or without shear wall using different type of investigation techniques. This review paper defined some of research reports on analysis of multi-story building with or without shear wall, effect of infill wall using Equivalent Lateral Force Method and Response Spectrum Method and other analysis technique. It also some investigation technique like Pushover Analysis, Time history Analysis on Existing regular or irregular building located in various area.
Keywords: Non Linear shear wall, plan irregularity, SAP2000, nonlinear time history analysis, pushover analysis etc

I. INTRODUCTION

High intensity of earthquake has expanded causing extreme harm to human life and property. Most of us must have the personally experienced earthquakes, and aware of them earthquake is something which causes the shaking of the earth. All building and structures erected on the earth's surface start trembling and when a quake comes. An earthquake is defined as the natural vibration of ground motion produced by forces i.e. seismic forces. Many vibrations are feeble, and may not even ne felt on any appreciate extent, by human beings. Some other vibrations may very severe, and may cause the collapse rupture of buildings and other structures, bringing large scale destruction and disaster in its wake. Seismic analysis is a subset of structural analysis and calculated by a response of a building.Structure to earthquakes. It is the part of the process of structural design. The analysis of methods are-

A. Equivalent Static Force Analysis

The equivalent static analysis is an simplified technique to substitute the effect of lateral or dynamic loading of an expected earthquake by a static force distributed laterally on a structure for design purposes. The totally applied seismic force V is regularly evaluated in two horizontal directions parallel to the main axes of the building. It assumes that the building responds in its fundamental lateral mode. For this , the building or structure must be low rise and must be fairly symmetric to avoid torsional movement underground motions. The building must be able to resist effects caused by earthquake forces in either direction, but not in both directions simultaneously.

B. Dynamic Analysis (Response Spectrum Method)

This approach permits the multiple modes of Response of building to be taken into account (in the frequency domain). This is required in many buildings codes for all except for very simple or very complex structures. The response of an structure can be defined as an combination of many special modes that in a vibrating string correspond to the Harmonics.. For each & every mode, a response is read from the design spectrum, based on the modal mass, and then they are combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination techniques includes- Absolute Peak values were added together (SRSS) 'Square Root of the Sum of the Squares ' and Complete Quadratic Combination (CQC) - a method that is the improvement on SRSS for closely spaced modes. The results of an response spectrum analysis using response spectrum from a ground motion is typically different from that would be calculated directly from an Response spec analysis, using that ground motion directly. Hence phase information is lost in the process of obtaining the response spectrum. In case, whether structures are either too irregular, too tall or significance to a community in the disaster response, the response spectrum approach is no longer appropriate or useful & in that case more complex analysis is required, such as non-linear static analysis or dynamic analysis.

C. Linear Dynamic Analysis

Static analysis are considered when higher mode effects are not significant. This is generally for short and regular building. Therefore a dynamic procedure is required, for all buildings, buildings with torsional irregularities, or non-orthogonal systems. In the linear dynamic Analysis, the building is modelled as an multi-degree-of- freedom (MDOF) system with linear elastic stiffness matrix & an equivalent viscous damping matrix. The seismic inputs are modeled using either time history analysis or modal spectral analysis where in both cases, the corresponding internal forces & displacement were determined using linear elastic analysis. The advantages of these linear dynamic analysis with respect to linear static analysis is that higher modes can be considered. However, they were based on linear elastic response & hence applicability decreases with increasing nonlinear behavior, which was approximated by global force reduction factor.

D. Nonlinear Dynamic Analysis

Nonlinear dynamic procedure utilizes the combination of ground motion records with an detailed structural model, therefore it is capable of producing result with relatively low or less uncertainty. In nonlinear dynamic procedure, the detailed structural model subjected to ground-motion record produced an estimates of component deformations for each degree of freedom(DOF) in the model & the modal responses are combined using schemes such as the square-root-sum-of- squares(SRSS).In non-linear dynamic procedure, the non- linear properties of the structure were considered as part of a time domain analysis. This approach is the most rigorous, & is required by some building codes for buildings of unusual configuration either of special importance. However, the calculated response can be very sensitive to the characteristics of the individual ground motion used as seismic input; therefore, various analyses are required using different ground motion records to achieve an reliable estimation of probabilistic distribution of structural response. Since the properties of the seismic response depended on severity, or intensity, of the seismic shaking, a comprehensive assessment calls for numerous nonlinear dynamic analyses at various levels of intensity to represent different possible earthquake scenarios. This lead to the emergence of methods like the incremental dynamic analysis.

E. Nonlinear Static Analysis

Linear analysis is useful when structure was expected to remain nearly elastic for the level of ground motion or design results are in nearly uniform distribution of nonlinear response throughout the structure. As the performance objective of the structure leads to greater inelastic demands, the uncertainty with linear procedures increases to point that requires an high level of conservatism in demand assumptions & acceptability criteria to avoid an unintended performance. Therefore, procedures incorporating inelastic analysis reduces the uncertainty & conservatism. These approach is also known as "pushover" analysis. A pattern forces is applied to a structural model that includes the non-linear properties (such as steel yield), & the total force is plotted against a reference displacement to define a capacity curve. Further it can be combined with a demand curve (acceleration-displacement response spectrum (ADRS). This reduces the problem to a single degree of freedom system. Nonlinear static procedures use equivalent Single Degree of freedom structural models and represent seismic ground motion with response spectra. Story drifts & component actions were related subsequently to the global demand parameter by the capacity or Pushover curves that are on the basis of the non-linear static procedures.

II. REVIEW PAPER

1) *Pramodini (2017)* analysed the importance of carry out performance based design for the RC building and investigates the seismic performance of 9 story residential apartment building located in the Panaji city of Goa. The building is designed as per IS456:2000 and seismic evaluation is carried out using Nonlinear pushover analysis. The analysis for pushover is carried using ETABS v9 software. The program which was developed by VBA for carrying out moment curvature analysis based on stress strain model for concrete & steel given in an IS 456:2000, for modelling plastic hinge properties of beam and column. The design

base shear building is compared with the base shear demand at demand earthquake. Further the global response of building in terms of pushover curve, hinge location & ductility ratio is studied for predicting the safety of the building at demand earthquake loading. He had concluded that the building is over safe from the result of safety and base force at performance point and hence the capacity of building is further reduced to some extent to achieve economy in design and it seen that the building model with user defined hinge is more ductile and has shown lesser base force at performance point compared to default hinge model.[26]

2) *M. K. Rahman (2012)* analyzed a 3D nonlinear static analysis for seismic performance evaluation of an already existing an eight-story reinforced concrete frame shear wall building in Madinah. The building contains dome, RC frame, elevator shafts and ribbed & flat slab systems at different floor levels. The seismic displacement response of reinforced concrete frame shear wall building obtained using the 3D pushover analysis. The 3D pushover analysis was carried out using SAP2000 software incorporating inelastic material behaviour for concrete and steel. Moment curvature and P-M interactions of frame members was obtained by cross sectional fiber analysis using XTRACT. The RC wall was modeled using mid pier approach. After his analysis, he concluded that Madinah Municipality building showed the building is deficient to resist seismic loading. Formation of hinges exactly showed that members of the building were designed purely on gravity loads as with a small increment of displacement, most of the members start yielding. Capacity curves show non-ductile behaviour of the building, where almost all the seismic load is carried by the RC walls & at very small displacement, hinges start forming in shear walls. This indicates that the strengthening of the shear walls in the building is compulsory required.[23]
3) *RezaAllahvirdizadeh (2016)* studied conventional nonlinear static analysis in his paper. In this regard, low to mid-rise moment-resisting RC frames were studied. The investigation contains evaluating capability of pushover analysis in predicting local and global performance criteria e.g. rebar/concrete strain, component chord rotations and inter-story drift. Two more common lateral load patterns i.e. inverted triangular (corresponding to first mode of vibration) and uniform (corresponding to seismic weight of each storey) were considered. Significant numbers of nonlinear time-history analysis are conducted to obtain statistically reliable outcomes. These responses were utilized for comparison aims. Results show that predicted mean responses by both considered lateral load patterns are satisfactory; the pushover procedure has considerable deficiency in identifying critical plastic region (place of nonlinearity concentration). Also, liner regression analysis between roof drift and maximum experienced inter-story drift data is conducted to validate assumption of transforming MDOF system to equivalent SDOF system. The scatter of this transformation increases by demands which emphasis on less accuracy of pushover analysis in larger nonlinearities (higher performance levels).[27]
4) *N. M. NIKAM(2016)* conducted the nonlinear static analysis of reinforced concrete building with and without shear wall using SAP2000 software. The main aim of his study is to examined the behaviour of building for different location of RC wall; the pushover analysis is carried out using finite element method based SAP 2000 software. The comparison is made between the structural responses of different building models within the different location of shear wall and he had taken G+15 and G+20 for comparison. After the analysis, he concluded that building with shear wall performs well than bare frame. And when comparison is made among the different location of shear wall, again corner and periphery shear wall proves better, as it increases the global stiffness and resist the applied load.[25]
5) *A. K. Mapari (2018)* analyzed the performance assessment of multi-story RC special moment resisting frames (SMRFs) and ordinary moment resisting frames (OMRFs) to compare the base shear capacity and ductility of the buildings using SAP2000 software. The nonlinear static analysis i.e. pushover analysis is adopted for studying the behaviour of SMRFs and OMRFs. The effect of infill walls are also taken into account in terms of base shear and roof displacement. The buildings response reduction factors are obtained from the pushover curves obtained for every modelled building by studying its behaviour parameters such as ductility reduction factor and over strength factor. For the analysis, four different type of storey height of building is taken as G+4, G+6, G+8 and G+10. After his analysis, he concluded that SMRF buildings attracts 39% to 43% less base shear than OMRF buildings in x direction, where as in *y*-directions SMRF buildings attracts 40% to 44% less base shear than OMRF buildings. In case of infilled frames, SMRF buildings attracts 2% to 25% and 9% to 24% less base shear than OMRF buildings in *x* and *y* directions respectively. It has also been seen that SMRF buildings in both x and *y* direction are more ductile than OMRF buildings. It is also noticed that initial stiffness of SMRF frames with infill walls increased drastically than SMRF bare frames as these frames attract much more base shear.[1]
6) *Azam (2013)* showed the configurations of RC moment resisting framed building structure with various arrangements of RC walls are considered for evaluation of seismic performance, so as to arrive at the suitable arrangement of RC wall in the structural framing system for good seismic resistance. A comparison of structural behavior in terms of stiffness, strength and damping characteristics is done by arranging RC walls at various locations/configurations in the structural framing system. The

in elastic nonlinear static pushover analysis as well as elastic response spectrum analysis analyses are carried out for the evaluation of seismic performance. The results of the study indicate that the provision of RC walls symmetrically in the outermost moment resisting frames of the building & preferably interconnected in mutually perpendicular directions forming a core will leads to better performance.[28]

7) *Y.Fahjan(2012)* evaluated on the consistency of different approaches for nonlinear shear wall modeling and for this purpose 3, 5 and 7-story reinforcement concrete (RC) frames with RC walls are analyzed using nonlinear 2-D nonlinear finite element method under constant gravity loads & incrementally increased lateral loads. The analysis results of all these models are compared in terms of overall structural behavior systems.. After his analysis, he comes to conclusion that,1.The RC wall with two layers of longitudinal & transverse reinforcement bars could be modeled with mid pier frame and multi-layer shell with plastic hinges to reflect the material nonlinearity. The plastic hinge properties of the RC wall could be defined using FEMA 356 recommendation or fiber-based hinge property. The pushover analysis based on FEMA 356 model & fiber model produced identical top displacement-base shear curves for the sample frames and these curves are approx. similar except multi-layer shell model for all cases.2. No. of plastic hinge locations is a major key for the accurate representation of the inelastic phenomenon for the Reinforced concrete shear walls. FEMA 356 model with two plastic hinges overestimates the capacity of the structure.3. Since the capacity curves for mid-pier frames with plastic hinges defined using FEMA 356 recommendation & fiber-based hinge property are identical with each other, reinforced concrete walls can be modeled using mid-pier frame with plastic hinges defined using FEMA 356 recommendation.[30]
8) *Arvindreddy (2015)* carried out seismic analysis of RC regular and irregular frame structures. The study showed that the results obtained from static analysis method are lessor in term of story displacement values as compared to response spectrum analysis.[8]
9) *Gottala and Shaikyajdhani (2015)* compared the static and dynamic seismic analysis of a multistorey building. The study shows bending moments are 35to 45 % higher for dynamic analysis than the values obtained for static analysis. The values for displacements of columns are 40 to 45 % higher for dynamic analysis than the values obtained for dynamic analysis; the values of nodal displacements in Z direction are 50% higher for dynamic analysis than the values obtained for static analysis. **[6]**
10) *Aman Mwafy and sayed khalifa* had take Five 50-story buildings are selected and designed using finite element models and international building codes to represent the most common geometrical vertical irregularities of RC tall buildings in regions of medium seismicity. Detailed fiber based simulation models are developed to assessing the seismic response of the five benchmark (BM) buildings under the effect of forty earthquake records representing near source and far field seismic scenarios. The results shows that a large number of inelastic pushover & incremental dynamic analyses provide insights into the local & global seismic response of the reference structures & confirm the inferior local response of RC tall buildings with very severe vertical irregularities. Due to the significant impacts of the severe irregularity types on the seismic response of RC tall buildings, the conservative code approach & coefficients were recommended for design. It's also concluded that although the design coefficients of buildings with moderate irregularities are conservative and they can be revised to arrive at more consistent safety margins & cost-effective designs.-The calculated deflection amplification factors for the reference irregular structures were significantly a lower than those recommended by the design code. For the structures with moderate irregularity, the response modification factors could be safely increased .more reduction is possible after the assessment of the structures designed using the proposed reduction in deflection amplification factors.[4]
11) *Ashraf Uddin et al [2013]* analyzed P-Delta effect in RC structures of rigid joint. 12 cases and 2 different analyses are performed to throw light into P-Delta effect in Reinforced concrete framed structures of rigid joints. He observed that, under P-Delta effect, displacement varies exponentially with increase in height or increment in stories. After his analysis, he concluded that both linear static and P-Delta analyses necessary for tall structures.[9]
12) *Yousuf Dinar et al [2013]* evaluated the deflection of tall steel structures under P-Delta effect. Linear static analysis had been done to observe the P-Delta phenomenon. The analysis had been done by using STAAD Pro software. They found that with wide variation in displacement with increase in slenderness, P-Delta analysis is required for structures taller than 7 storeys.[32]
13) *P V Dhanshetti et al [2015]* investigated the action of P-Delta effect on multi-storey buildings. In his work, he showed multi-storeyed reinforced concrete building models with different no. of storeys was analyzed by using STAAD Pro software. It was observed that the P- Delta effect is necessary when lateral forces exist on the structure and it increases with increase in no. of storey. The P-Delta effect is not necessary on buildings up to seven storeys and it is very negligible when only gravity loading exists on the structure.[10]
14) *M. F. Huang(2015)* showed a integrated computational design optimization method for the performance based design(PBD) of

high rise building subjected to different levels of wind excitation. A performance based wind engineering design framework is proposed by defining various performance objectives associated with multiple level of wind hazards. A pushover analysis is used to predict the inelastic drift performance of high rise building subject to very rare extreme wind events. The optimal performance based design problem considering inelastic deformation is formulated and solved by the augmented optimality criteria method. The effectiveness & practicability of the optimal wind resistant performance based design (PBD) techniques are illustrated by a practically 40 storey Residential building.[22]

15) *Junwon Seo(2015)* evaluated the seismic performance of a 12 story RC moment-resisting frame structure with RC walls using 3D finite element models according to such seismic design regulations as Federal Emergency Management Agency (FEMA) guideline & seismic building codes including Los Angeles Tall Building Structural Design Council (LATBSDC) code and the structure is located in Seismic Zone 4, considering the highest-seismic-risk classification established by the U.S. Geological Survey. 3D finite element model was generated in commercially available finite element software. In seismic performance evaluation, two standard approaches were used; response spectrum analysis and nonlinear time-history analysis. But both the approaches were used to compute inter-story drift ratios of the structure. Seismic fragility curves for each floor of the structure were obtained using the ratios from the time history analysis with the FEMA guideline so as to evaluate their seismic vulnerability. The ratios of both approaches was compared to FEMA & LATBSDC limits. The findings reveal that the floor level fragility mostly decreased for all the FEMA performance levels with an increasing in height & the ratios from both approaches mostly satisfied the codal limits.[18]
16) *Ketan Kulkarni(2015)* studied the behavior of RC walls using both modelling approach for walls with different aspect ratio & amount of longitudinal reinforcement. It is observed that while both the modelling approaches help in estimate initial stiffness adequately, estimates are not good for lateral strength & ductility capacities of shear walls modelled using multilayer shell element, particularly for square walls expected to fail in the shear. After his analysis, he concluded that while both modelling approaches are needed for linear elastic analysis, as required in routine design, modelling using multilayer shell element is not appropriate for undertaking pushover analysis for assessment of seismic behavior of buildings with shear walls.[21]
17) *Guray Arslan(2016)* designed eight different five- and seven storey reinforced concrete frame buildings with & without beam discontinuity in plan & with different torsional irregularities, according to Turkish Seismic Code 2007(TS 2007) & performance evaluation of this buildings were carried out using different analysis methods:(1) linear elastic method (LEM), (2) nonlinear static procedure (NSP), and (3) nonlinear time history analysis (NTA).. It is observed that Nonlinear static procedure delivers closer results to the results of Nonlinear time history than Linear Elastic Method does when the considered building in- plan irregularity. Using Linear Elastic Method in performance evaluation of in plan irregular building can yield unreliable & conservative results. After his analysis, he concluded that if torsional irregularity without beam discontinuity is smaller than the codal limits, it may not have an considerable effect on seismic performance of buildings.[14]
18) *Amar (2014)* evaluated the Seismic behavior factor R of reinforced concrete frame based on comparative analysis between non-linear static pushover and non-linear incremental dynamic analyses. .For this purpose, three-, six-, and nine- storey reinforced concrete frame.[5]
19) *Kai Hu, Yimeng Yang , Suifeng Mu , Ge Qu, Procedia Engineering 31 (2012)* presented a paper on study on high-rise structure with oblique columns by ETABS, SAP2000, MIDAS/GEN and SATWE. The main aim of these paper was to execute Response spectrum, Time history(THA) and Linking slab in-plan stresses analysis combined with a practical project, by using the software programs SAP 2000, MIDAS/GEN and SATWE, which was also compared. The project was located in the Shanghai. The main structure was a 29-storey building, including 3 floors underground & 26 floors above ground. The results given by all softwares were compared and proposes that Slab as the important lateral force resistant component, should not be ignored in design works, especially to those complex structures, the slabs stress analysis at weaken positions is very essential.[20]
20) *Nayas and antony (2017)* analyzed plan irregular RC frame with special shaped columns using nonlinear static pushover analysis. After his analysis, he concluded that Base shear value shall be least for L shaped building so this type should be avoided in earthquake zone areas. The base shear capacity of T shaped building is increased by providing T shaped column in the re-entrant corners.[7]
21) *Fabio Mazza, Engineering Structures 80 (2014)* presented a paper on Modeling and nonlinear static analysis of reinforced concrete framed buildings irregular in plan. The objective of this study was to assess the seismic vulnerability direction of RC framed building with asymmetric plan in terms of displacement & strength. The case study selected is for the existing town hall of Spiling a small town near Vibo Valentia (Italy), which was a two-storey reinforced concrete framed structure, with an L-

shaped irregular plan. A lumped plasticity model with a flat surface modeling of an axial load–biaxial bending moment elastic domain of reinforced concrete cross- sections is implemented in a computer code for the pushover analysis of R.C spatial framed structures. He finally highlight that, in case of in-plan irregularity, the use of capacity domains revealed essential to estimate the directions of least seismic capacity.[11]

22) *T. Mahdia and V. Bahreini, Procedia Engineering 54 (2013)* in his paper on "Seismic response of asymmetrical infilled concrete frames." The aim of this paper was to evaluates the nonlinear seismic behavior of intermediate moment-resisting RC space frames with asymmetrical plan in three, four and five storeys. Analyses of these buildings were made with and without considering the masonry infill . The main points observed from this study is on comparing uniform and triangular distributions of lateral loads, triangular distributions yield higher values & different vertical load combinations make no significant differences in the results. Columns forces in infilled frames are smaller than the corresponding ones in bare frames. Bare frames are more vulnerable than infilled frames. [29]
23) *Hendramawat A Safarizki, S.A. Kristiawan, and A. Basuki, Procedia Engineering 54 (2013* **)** presented a paper on 'Evaluation of the use of steel bracing to improve seismic performance of reinforced concrete building'. The objective of this paper was to evaluate the possible improvement of seismic performance of existing RC building with the use of steel bracing. The three methods of seismic evaluation were employed for these i.e. Nonlinear Static Pushover Displacement Coefficient Method by FEMA356 guidelines, Improvement of Nonlinear Static Pushover Displacement Coefficient Method but FEMA 440 & Dynamic time history analysis following the Indonesian Code of Seismic Resistance Building criteria. After his analysis, the author concluded that Steel bracing could be utilized for seismic retrofitting of the 5th Building of UNS Engineering Faculty. Both nonlinear static pushover analysis based on FEMA 356 & FEMA 440 & dynamic time history analysis confirmed this.[15]
24) *G. Uva(2016)* showed an extensive case study regarding the analysis of an existing Reinforced concrete framed building located in a high seismic risk zone area in Calabria (Southern Italy), for which the project, dated back to the early '70s, provided only the presence of vertical loads. In order to collect the data required for the application of the safety assessment procedure and achieve the necessary knowledge level, a broad experimental test campaign was performed on building in order to assess the condition and quality of both Reinforced concrete elements & infill walls. A number of non-linear static pushover analysis was performed on proper structural models of the building, considering both the infilled frame and bare frame structure, in order to appraise the influence of infill walls on the failure mechanism. In particular, a sensitivity analysis was performed by assigning different Partial Safety Factors to the mechanical parameters of infill walls, in order to investigate their effect on the overall structural response of the building.[13]
25) *Raju(2010)* showed a typical 6-storey RC building frame is designed for four design cases as per the provisions of IS: 1893 & IS: 456 & it is analyzed using user-defined nonlinear hinge properties or default-hinge properties, given in SAP 2000 based on the FEMA-356 & ATC-40 guidelines. An analytical procedure is developed to evaluate the yield, plastic and ultimate rotation capacities of reinforced concrete elements of the framed buildings & these details are used to define user-defined inelastic effect of hinge for beam M3 curves and for column as P-M-M curves. A simplified three parameter model is used to find the stress–strain curves of reinforced concrete elements beyond the post yield region of confined concrete. Building performance of structural components in terms of target building performance levels are studied with the pushover analysis. The possible differences in the results of nonlinear static analysis due to default- and user-defined nonlinear component properties at various performance levels of the building are studied.[19]
26) *Naphade and patil (2015)* analyzed the G+10 RC building with soft storey at different levels using nonlinear static pushover analysis in SAP2000 software. Shear wall also incorporated to enhance the performance of the building. It can be concluded from the results that soft storey is safe at higher levels in the building. Most of the plastic hinges was developed in beam and less were developed in columns. Plastic hinges developed in ground storey columns did not satisfy the acceptance criteria for safe design. The buildings was retrofitted using shear wall which does not allow the formation of plastic hinges in ground storey columns thus, provide better resistance to soft storey effect during seismic event.[3]
27) *Rahman(2010)* presented a a 3D pushover analysis for seismic performance evaluation of an existing eight-story RC frame-shear wall building in Madinah. The building contains dome, RC frame, elevator shafts and ribbed and flat slab systems at different floor levels. The seismic displacement response of the RC frame-shear wall building is obtained using the 3D pushover analysis. The 3D static pushover analysis was carried out using SAP2000 incorporating inelastic material behavior for concrete and steel. Moment curvature & P-M interactions of frame members was obtained with cross sectional fiber analysis using XTRACT. The RC wall was modeled using mid-pier approach. The damage modes includes a sequence of yielding & failure of

members & structural levels were obtained for the target displacement expected under design earthquake and retrofitting strategies to strengthen the building were evaluated.[23]

28) *Abazar(2017)* showed the results of linear, non- linear static (pushover), & nonlinear inelastic time-history analyses of a ten story structure with 2-D RC wall(CSW) which are perforated using three different patterns taken from the S22 stress of shell elements of RC walls. Pushover analysis results confirmed that perforation can increase the response modification factor R of coupled walls up to 33 percent. Further results shows that linear analysis & design indicate that perforation can reduce the required reinforcement of coupling beams & other frame's structural components. Further results shows of nonlinear inelastic time history analysis confirm that, using perforation patterns, the base shear roof displacement hysteretic response improves & the systems with perforation patterns can absorb more energy under severe earthquakes different patterns taken from considering the S22 stress of shell elements of RC walls. Non Linear static analysis results confirmed that perforation can increase the response modification factor of coupled walls up to 33 percent. Further the results of linear analysis & design indicate that perforation can reduce the required reinforcement of coupling beams & other frame's structural components. Further results of nonlinear inelastic time-history analysis confirm that, using perforation patterns, the base shear roof displacement hysteretic response improves & the systems with perforation patterns can absorb more energy under severe earthquakes.[2].

III.CONCLUSIONS

From Literature review, it is found that,

A. Seismic Performance evaluation of Inplan Irregular (Beam Continuity and Beam Discontinuity in plan) RC Frame with shearwall has not been done yet.
B. Behaviour of Mid-pier element of shearwall modelling with regular and irregular building has not been studied.
C. Behaviour of Multi-layer shell element of shearwall modelling with regular and irregular building has not been studied.
D. Participation of shearwall at performance point with mid-pier element and multi-layer shell element has not been found.
E. Over strength factor for Mid-pier element and Multilayer shell element with RC Frame has not been found.

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