A Review Paper on Study of plan Irregularity of High Rise Steel Building With And Without Bracing

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Abstract- *Irregularities in structure, as a result of the limitations of architectural, performance and finance are one of the issue considered unavoidable in many unburn structures this study examines the seismicbehavior of steel structure with plan irregularities including mass strength and stiffness structural. Mass irregularity is considered to exist where the seismic weight of any story is more than 200% of that of its adjacent story. Mass irregularity is an important factor which affects the response of the structure under seismic load. This is introduced by increasing the weight of some floors relative to the other floors. The effect of irregularity depends on the structural model use location of irregularity and analysis method. An attempt is made to study the behavior of irregularity by providing eccentric bracing. Hence the response of steel building with different masses is evaluated.*
Due to such asymmetric structures along with governing seismic forces leads to the torsional irregularity. This irregularity causes mainly due to shift of center of mass from center of gravity.

Keywords- Plan irregularity, Torsional irregularity, Mass irregularity, Steel structure, Eccentric bracing.

I. INTRODUCTION

mong categorizations of seismic behaviour that have been adopted in modern codes is extreme torsional irregularity. Torsional irregularity is not an unfamiliar concept, having been expressed in codes in various forms for decades. It is an issue that engineers have learned to deal with, particularly in seismically active areas. Extreme torsional irregularity, however, is a somewhat newer concept and subset within the larger issue of torsional behaviour. It is something that can greatly limit and restrict flexibility in choosing seismic force-resisting systems and configurations.

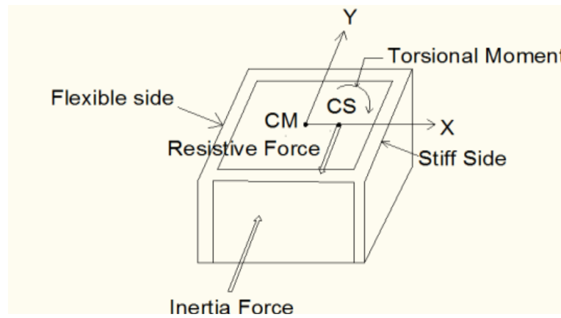

Fig 1 Generation of torsional moment in asymmetric structures

Recent codes have defined torsional irregularity as the condition where the maximum story drift, including accidental torsion, at one end of the structure transverse to an axis is more than 1.2 times the average of the story drifts at the two ends of the structure. A little pencil work will show this means that if one end of a rectangular structure drifts more than 1.5 times the other end, torsional irregularity is said to exist. For the newer category of extreme torsional irregularity, the calculation steps are fundamentally the same, but this designation is assigned to structures where the maximum story drift, including accidental torsion, at one end of the structure transverse to an axis is more than 1.4 times the average of the story drifts at the two ends of the structure. Again, in simple terms, this means that if one end of a rectangular structure drifts in excess of 2.33 times the other end, extreme torsional irregularity is said to exist.

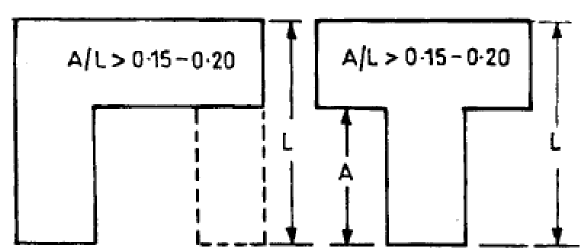

Fig 2: Examples of building with plan irregularities

II. REVIEWOF PREVIOUSSTUDIESON PLANIRREGULARITIES

2.1.Nonika. N, Gargi Danda De, ''SEISMIC ANALYSIS OF VERTICAL IRREGULAR MULTISTORIED BUILDING''

It is understood that buildings which are regular in elevation (regular building) perform much better than those which have irregularity in elevation (irregular building) under seismic loading. Irregularities are not avoidable in construction of buildings. However a detailed study to understand structural behaviour of the buildings with irregularities under seismic loading is essential for appropriate design and their better performance. The main objective of this study is to understand the effect of elevation irregularity and behaviour of 3-D R.C. Building which is subjected to earthquake load. In the present study, a 5 bays X 5 bays, 16 storied structure with provision of lift core walls and each storey height 3.2 m, having irregularity in elevation, is considered as the soft storey 3-D structure. An Irregular building is assumed to be located in all zones. Linear dynamic analysis using Response Spectrum method of the irregular building is carried out using the standard and convenient FE software package. To quantify the effect of different degrees of irregularities all the structures are analysed. In addition, the analysis carried out also enables to understand the behaviour that takes place in irregular buildings in comparison to that in regular buildings. For this the behaviour parameters considered are 1) Maximum displacement 2) Base shear, 3) Time period.

2.2 Robert Tremblay, and Laure Poncet, ''Seismic Performance of Concentrically Braced Steel Frames in Multistory Buildings with Mass Irregularity''

The influence of mass irregularity on building seismic response is examined for an eight-story concentrically braced steel frame with different setback configurations resulting in sudden reductions in plan dimensions and seismic weight along the height of the structure. Three locations of mass discontinuity were considered 25, 50, and 75% of the building height, together with two ratios of seismic weight 200 and 300%. A reference regular structure was also considered for comparison. The design of each structure was performed according to the proposed 2005 National Building Code of Canada NBCC provisions using two analysis methods: The equivalent static force procedure and the response spectrum analysis method. Although severe, the mass irregularity conditions considered in this study were found to have a limited negative impact on the seismic performance of the structures designed with the static analysis method. The performance of irregular structures exhibiting lower performance could be improved by using the dynamic analysis method in design, but not to the level achieved by the reference regular structure. Nonlinear dynamic analyses were performed on eight-story braced steel frames with severe mass irregularity subjected to an ensemble of 10 earthquake ground motions. The performance of a reference regular structure was also examined. Each structure was designed using both the equivalent static force procedure and the dynamic response spectrum analysis method. Forces and deformations from dynamic analysis were scaled such that the dynamic base shear was equal to the base shear from static force procedure. The use of the dynamic analysis generally resulted in larger brace sizes in the upper levels and smaller braces in the intermediate levels. Overall, the analysis method had no significant effect on the building periods and the steel tonnage required for the bracing bent. According to IBC 2003.

2.3 Elena MOLA , Paolo NEGRO, Artur V. PINTO, ''EVALUATION OF CURRENT APPROACHES FOR THE ANALYSIS AND DESIGN OF MULTI-STOREY TORSIONALLY UNBALANCED FRAMES'' August 1-6, 2004

Plan-wise irregular buildings are quite common in many earthquake-prone areas of Europe and worldwide, making up a remarkably important category of existing structures. Irregular structures exhibit a complex behaviour under unit- or bi-directional seismic excitation because of Torsional coupling effects affecting the response; due to the inherent complexity of the problem only simplified models have been developed and studied so far and a number of open issues still exist on the subject. Experimental activity is therefore badly needed in order to validate analytical studies and to point out the way for their future developments. In the framework of the research activity of the ELSA Laboratory of the Joint Research Centre, bi-directional pseudo-dynamic testing of a real size plan-wise irregular 3-storey frame structure was carried out in January 2004, as the core of a 3-year research project named SPEAR (Seismic Performance Assessment and Rehabilitation). The SPEAR project, specifically targeted at existing buildings, pursues the aim of improving current codified approaches to the assessment of older non-seismically designed structures, by means of a balanced combination of numerical and experimental activity. The data made available by the unique SPEAR experimental activity are very important in themselves, given the scarcity or absence of test data on the behaviour of irregular multi-storey structures; in the present paper, they have been compared to the predictions resulting from the application, to the same structure, of current codified assessment approaches, thus allowing some conclusions to be drawn on the effectiveness of the latter in dealing with torsionally unbalanced buildings.

2.4 Prof. M.R.Wakchaure, Anantwad Shirish, Rohit Nikam, ''Study Of Plan Irregularity On High-Rise Structures'' October, 2012

This paper aims at studying description of different plan irregularities by analytical method during seismic events. In all the studied systems from which dual system is chosen for analysis and studying its effects on different irregularities in which analysis is based on the variation of displacements, with respect to structural systems. Analyses have been done to estimate the seismic performance of high rise buildings and the effects of structural irregularities in stiffness, strength, mass and combination of these factors are to be going to be considered. The work describes to the irregular plan geometric forms that are repeated more in the metro city areas such as Mumbai like T-section and Oval Shape plan geometry. These irregular plans were modelled in ETABS 9.7v considering 35 and 39 storied buildings, to determine the effect of the plan geometric form on the seismic behaviour of structures with elastic analyses. Also, effects of the gust factor are considering in T-shape and Oval Shape plans. Although these affects mainly on the architectural plan configuration, plan irregularity find better structural system solution such as dual system has been use for structural analysis. In structural configuration shear wall positions located are located in the form of core and columns are considered as gravity as well as lateral columns. Two types of models are going to be developed namely strength & serviceability models. In strength model all the lateral systems (i.e. shear walls and coupling beams) are to be analyzed. The purpose of study was to analyze plan irregularities on high-rise structures and to observe the behaviour of structures. For this, ETABS a linear dynamic analysis and design program for three dimensional structures has been used. Dynamic analysis has-been carried out to know about deformations, natural frequencies, time periods, floor responses and displacements.

2.5 Rucha S. Banginwar, M. R. Vyawahare , P. O. Modani, ''Effect of Plans Configurations on the Seismic Behaviour of the Structure By Response Spectrum Method''

The bahaviour of building during earthquake depends critically on its overall shape, size and geometry. Building with simple geometry in plan have performed well during strong past earthquake but building with u, v, H & + shaped in plan have sustained significant damage. So the proposed project attempts to evaluate the effect of plan configurations on the response of structure by RSM(response spectrum method) The Indian Standard Code (IS-Code) of practice IS-1893 (Part I: 2002) guidelines and methodology are used to analyse the problem. In this proposed work the study is carried on the effect of difference geometrical configurations on the behaviour of structure of the already constructed building located in the same area during earthquake by RSM in this paper, more emphasis is made on the plan configurations and is anlysed by RSM since the RSM analysis provides a key information for real – world application.

2.6 Kien Le-Trung ,Kihak Lee and Do-Hyung Lee, ''SEISMIC BEHAVIOR AND EVALUATION OF STEEL SMF BUILDINGS WITH VERTICAL IRREGULARITIES'' October 12, 2008

This paper concentrates on investigating the seismic behaviors of vertically irregular steel special moment frame (SMF) buildings by comparison with the regular counterpart. All buildings of this study were assumed to locate in Los Angeles and subjected to 20 earthquake ground motions with a seismic hazard level of 2% probability of exceedance in 50 years. These 20-story buildings were designed to conform to the requirements for steel SMFs as specified by IBC 2000 provisions, and the beam-column connections of the buildings were modeled to consider the panel zone deformation. Also, a ductile connection model accompanied by strength degradation was incorporated to the analysis program in an effort to obtain more accurate response results. Three types of the irregularities (mass, stiffness and strength irregularity) specified as vertical irregularities in the IBC 2000 provision were imposed to the original building. Nonlinear static and dynamic analyses were performed, and the confidence levels of which the performance objective will be satisfied were calculated as well. The effects of different irregularity types and levels on the seismic behaviors of the buildings were investigated and discussed in terms of the height-wise distribution.

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2.7 Poncet, L. and Tremblay, R, ''INFLUENCE OF MASS IRREGULARITY ON THE SEISMIC DESIGN AND PERFORMANCE OF MULTI-STOREY BRACED STEEL FRAMES'' August 1, 2004

The influence of mass irregularity is examined for an eight-storey concentrically braced steel frame with different setback configurations. Three height locations of mass discontinuity and two ratios of seismic weight were considered. A regular structure was also studied for comparison. Both the equivalent static load method and the response spectrum analysis method were used in design. Mass irregularity was found to have limited impact on collapse prevention when static analysis was used. For irregular structures exhibiting lower performance than the regular frame, the response was improved by adopting dynamic analysis but not to the level achieved with the regular structure.

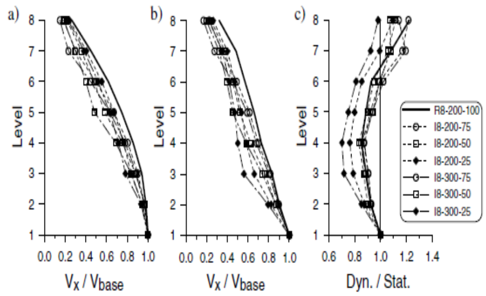

Figure 2: Vertical distribution of the storey shears: a) Static analysis; b) Dynamic analysis; c) Ratio of dynamic to static analyses.

Figure 2 compares the vertical distribution of the storey shears for static and dynamic analyses. Fromdynamic analysis, the storey shears are generally lower in the intermediate floors and higher in the topfloors. The reduction is more pronounced for the I8-α-25 buildings while the increase in the upper levelsis more important for I8-α-75 and the regular structures.

Table 3. Ratio of brace cross section areas in dynamically to statically designed structures.

Building/ Level	200-100	200-75	200-50	200-25	300-75	300-50	300-25
8	-	1.30	1.30	1.30	1.30	1.30	-
7	1.04	-	-	-	-	-	-
6	-	-	0.82	-	-	-	-
5	0.87	-	0.85	0.82	-	-	0.82
4	0.97	-	0.96	0.85	0.97	-	0.70
3	-	-	0.85	0.82	0.87	0.87	0.82
2	0.87	0.97	-	-	-	0.97	-
1	-	-	-	-	-	-	-

Table 3 gives the changes in brace cross-sectionsthat were made in dynamic analysis compared to static analysis. As indicated, brace capacity wasincreased in the upper part of the buildings and reduced in the intermediate and lower floors. For the I8-300-25 structures, only brace reduction took place. Beam and column sizes in dynamic analysis designwere adjusted after the braces were selected, following accepted capacity design procedure.

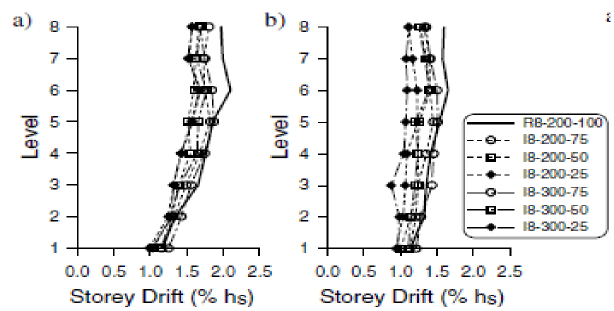

Figure 3: Anticipated storey drifts from: a) Static analysis; b) dynamic analysis.

Figure 3 shows the computed storey drifts from anticipated inelastic deflections for all structures. In allcases, the drifts are lower than the code limit and, hence, drift requirements did not govern the design. Asshown, lateral deformations from dynamic analysis are generally lower than those from static analysis.

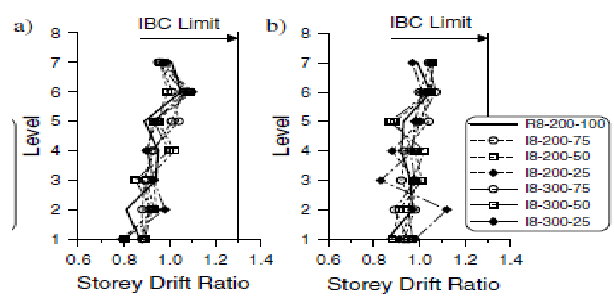

Figure 4: Ratios of storey drifts to the storey storey drifts at the storey above from: a) static analysis; b) dynamic analysis.

InFig. 4, the variation in drifts from one storey to the storey above is given for both methods of analysis. Forall buildings, the variations are well below the 1.30 limit allowed in IBC 2003 and all buildings wouldtherefore, qualify as regular structures according to that code document

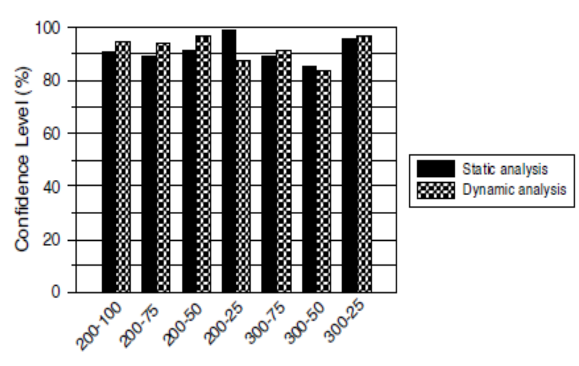

Figure 10: Confidence levels for collapse prevention

Figure 10 illustrates the variation of the confidence levels forthe different structures and designs.For the regular structures, the computed confidence levels for the collapse limit state just meet theacceptance level of 90% when designed with the static analysis procedure, which seems to confirm theadequacy of the 8-storey height limit specified in CSA-S16 for Type MD concentrically braced steelframes. The application of a dynamic analysis procedure for the regular structure increased the level ofconfidence by 4%. Such a slight improvement suggests thatdynamic analysis could have resulted inlower performance than static analysis, had the 20% relaxation on Vd been considered in dynamicanalysis, as permitted in the 2005 NBCC for regular structures. With the exception of the I8-300-50building, the confidence levels determined for the irregularstructures designed with the static method aresimilar to or better than those obtained for the reference R8-200-100-S structure. For the I8-300-50-Sstructure, the confidence level against collapse decreased by 5.5% compared to the regular structure withstatic analysis.

2.8 ThiThi Hein Lwin, Kyaw Lin Htat, "Study on Effect of High Rise Steel Building with Different Masses" 7, July 2015

This paper presents twelve-storeyed steel building with different masses which is situated in seismic zone IV. In this study, computer–aided analysis and design of superstructure for this building is carried out by using ETABS software. One regular building and three irregular buildings are compared. They have same plan size. The overall height is 129 ft and it is L-shaped. In these cases, mass irregularity is considered at bottom floor, middle floor and top floor of the proposed building. It is composed of special moment resisting frame (SMRF). Dead loads, superimposed dead loads, live loads, wind loads and earthquake loads are considered based on UBC-97. All structural members are designed according to AISC-LRFD 1999. Wide flange W-sections are used for frame members. Structural steel used in building is A572 Grade 50 steel. Structural stability checking (overturning moment, sliding, storey drift, torsional irregularity and P-Δ effect) are carried out for the stability of the superstructure. After checking the stability, the proposed building is analysed with time history analysis case. Suitable bracing types such as X-bracings are used in this case. The response of steel building with different masses is investigated. The drifts, shear, moment, displacement of stories of building with different masses are compared. Comparison of mode shape and time and internal forces of interior column are investigated. In this paper, storey drift, storey shear, storey moment and story displacement from static analysis are smaller than that of dynamic analysis. From the analysis results, it is found that the buildings with vertical structural irregularity have lower performance than the regular buildings. R=regular building, B-3= mass increased 3 floors in bottom, M-3= mass increased 3 floors in middle, T-3= mass increased 3 floors in top.

A. Comparison of Axial Force For Interior Column

The comparison of axial force for interior columns of regular and irregular buildings is graphically shown in figure 1.

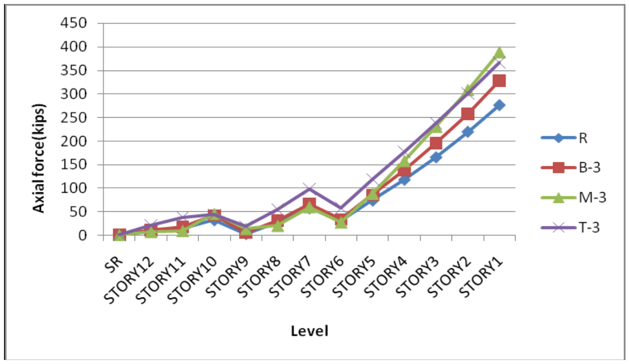

Figure 1. Comparison of Axial Forces for Interior Column C3 In the comparison of axial force, the maximum axial force is occurred at T-3 which is 1.32 times greater than that of regular buildings.

B. Comparison of Shear Force for Interior Column

The comparison of shear force for interior columns for regular and irregular buildings are graphically shown in figure 2.

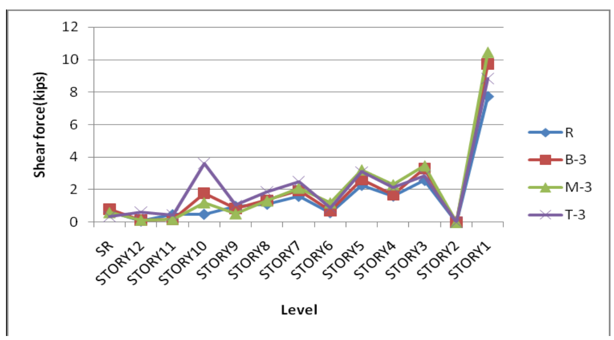

Figure 2. Comparison of Shear Forces for Interior Column C3 In comparison of shear force, the maximum shear force of M-3 is 1.35 times greater than that of regular building.

C. Comparison of Bending Moment for Interior Column

The comparison of bending moment for interior columns for regular and irregular buildings are graphically shown in figure 3.

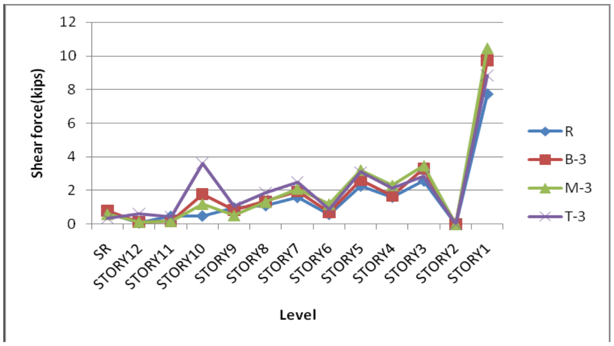

Figure 3. Comparison of Bending Moment for Interior Column C3

In the comparison of bending moment, the maximum moment of M-3 is 1.35 times greater than that of regular building.

D. Comparison of Torsion Force for Interior Column

The comparison of torsion force for interior columns for regular and irregular buildings are graphically shown in figure 4.

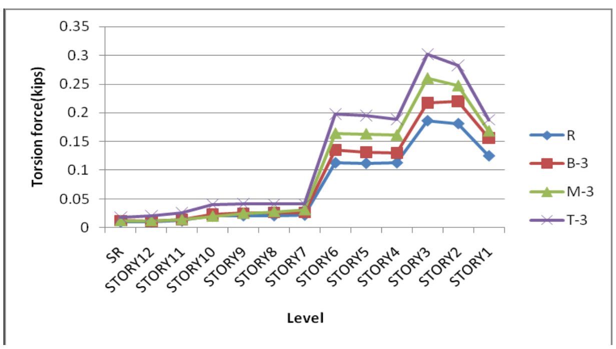

Figure 4. Comparison of Torsion Force for Interior Column C3

In comparison of torsion force, the maximum torsion force of T-3 is 1.5 times greater than that of regular building.

2.9 T.L. Karavasilisa , N. Bazeosa , D.E. Beskos, ''Seismic response of plane steel MRF with setbacks: Estimation of inelastic deformation demands'' 8 December 2007

An extensive parametric study on the inelastic seismic response of plane steel moment resisting frames (MRF) with setbacks is presented. A family of 120 such frames, designed according to the European seismic and structural codes, are subjected to an ensemble of 30 ordinary (i.e. without near-fault effects) earthquake ground motions scaled to different intensities in order to drive the structures to different limit states. The statistical analysis of the created response databank indicates that the number of stories, beam-to-column strength ratio, geometrical irregularity and limit state under consideration strongly influence the height wise distribution and amplitude of inelastic deformation demands. Nonlinear regression analysis is employed in order to derive simple formulae which reflect the aforementioned influences and offer, for a given strength reduction (or behaviour) factor, three important response quantities, i.e. the maximum roof displacement, the maximum interstate drift ratio and the maximum rotation ductility along the height of the structure. A comparison of the proposed method with the procedures adopted in current seismic design codes reveals the accuracy and efficiency of the former.

In an effort to examine and evaluate the seismic inelastic deformation demands in setback steel MRF designed according to the guidelines of current seismic codes, an extensive analytical parametric study was undertaken. A family of 120 code-compliant setback steel MRF were subjected to an ensemble of 30 ordinary (i.e. without near-fault effects) earthquake ground motions scaled to different intensities in order to drive the structures to different performance levels. It has been found that the level of inelastic deformation and geometrical configuration play an important role on the height wise distribution of deformation demands. In general, the maximum deformation demands are concentrated in the "tower" for tower-like structures and in the neighborhood of the setbacks for other geometrical configurations. The latter conclusions are more evident for high levels of inelastic deformation but they do not hold true for setback frames in the elastic range of the seismic response. Based on regression analysis, a procedure in terms of simple formulae for estimating the maximum roof displacement, the maximum interstate drift ratio and the maximum rotation ductility along the height of a setback steel frame, was developed. The procedure does not indicate where in the structure the maximum drifts will occur. Moreover, it does not depend on pushover analysis, since it demands only an elastic analysis up to the point of the development of the first plastic hinge in the building and therefore, is suitable for both seismic assessment of existing structures and direct deformation-controlled seismic design of new ones. It takes into account the influence of various structural characteristics of a setback steel frame, such as the number of stories, the geometrical irregularity and the beam-to-column strength ratio. Compared with the procedure adopted by current seismic design codes, it was found to be more accurate and efficient for performance-based seismic design of plane steel moment resisting frames with setbacks.

2.10 Komal R. Bele1 , S. B. Borghate, ''Dynamic Analysis of Building with Plan Irregularity'' June, 2015

IS 1893 (part1):2002 describes various types of irregularities in building as per clause 7.1 and suggests Dynamic analysis by Time History Method (THA)or Response Spectrum Method (RSA) for irregular buildings. Equivalent Static Analysis (ESA) based on empirical time period is suggested for Regular building. From previous research it is seen that behaviour of irregular building during earthquake is more vulnerable. In irregular building excessive stresses or forces may develop in particular portion of the structure which may cause severe damage during earthquake. It is necessary to identify the performance of such building during earthquake and design it for better performance. This paper is focused on irregularity in plan due to Re-entrant corner. Buildings with large projections of Re-entrant corners results in torsion.

Base ShearVb by THA {in KN}				
Model	THAX		THAY	
	Fx	Fy	Fx	Fy
R	5578	0	0	5641
L1	5290	45	45	5276
L2	4929	42	42	5002
L3	4414	61	60	4504
L4	4143	106	102	4219
L5	3593	221	214	3644

They concluded by ESA gives same time period for all regular and irregular building. While dynamic analysis gives different time period for regular and irregular buildings.ESA gives different values of Base shear for all regular and irregular building. Base shear decreases from Model R to L5. RSA gives different and less value of base shear than ESA.THA gives lesser value of Base shear than RSA. For ESA and RSA base shear value in Y-direction is more than X direction but it is not necessary for THA. For Irregular models, x-directional RSA and THA gives Base shear value in y direction; this is due to coupling of modes. It is seen that as projection of Re-entrant corner increases (for L1 to L5) the more coupling of modes occurs. RSA using modal combination SRSS gives more coupling of modes while CQC give less coupling. Result of forces in column (common in all building) shows that the variation of P much higher (from L1 to L5).

2.11 Eggert V. Valmundsson1 and James M. Nau, ''SEISMIC RESPONSE OF BUILDING FRAMES WITH VERTICAL STRUCTURAL IRREGULARITIES''

Earthquake design codes require different methods of analysis for regular and irregular structures, but it is only recently that codes have included specific criteria that define irregular structures. In this paper, the mass, strength, and stiffness limits for regular buildings as specified by the Uniform Building Code (UBC) are evaluated. The structures studied are two-dimensional building frames with 5, 10, and 20 stories. Six fundamental periods are considered for each structure group. Irregularities are introduced by changing the properties of one story or floor. Floor-mass ratios ranging from 0.1 to 5.0 are considered, and first-story stiffness and strength ratios varying from 1.0 to 0.5 are included. The response is calculated for design ductility levels of I (elastic), 2, 6, and 10 for four earthquake records. Conclusions are derived regarding the effects of the irregularities on shear forces and maximum ductility demands. It is found that the mass and stiffness criteria of UBC result in moderate increases in response quantities of irregular structures compared to regular structures. The strength criterion, however, results in large increases in response quantities and thus is not consistent with the mass and stiffness requirements. Based on these findings, several modifications to the criteria are proposed, which include a revised formula for estimating the fundamental period for buildings with no uniform distributions of mass.

III. ECCENTRICBRACING

Moment Resisting Frames (MRF) and Concentrically Braced Frames (CBF) are the mostcommonly utilized systems of the LFRSs permitted in ANSI/AISC 341-10 *Seismic Provisionsfor Structural Steel Building* (AISC 341). MRFs have a high level of ductility, making them anexcellent option to dissipate energy for high seismic events, such as those that occur when astructure is in SCD D, E, or F. However, the high level of ductility comes at a cost: a low levelof lateral stiffness. MRFs have a lower level of lateral stiffness than CBFs since they lackbraces, and the low lateral stiffness of MRFs can cause story drift at levels exceeding driftlimitations. As such, MRFs are designed around drift instead of strength, resulting in reducedeconomy. Conversely, CBFs have a high level of lateral stiffness and a low level of ductility.For CBFs to be utilized in high seismic regions, special detailing is required to ensure that theframes behave in the prescribed manner. In the 1970s, a new set of frame configurations, shownin Figure 3-1, was proposed for seismic design that would combine the advantages of MRFs andCBFs while decreasing the disadvantages; the seismic-resisting EBF is the product of decades ofresearch. Figure 3-1a depicts a modified chevron configuration in which there is one mid-beamlink per level; the braces of the above level could be inverted toform a modified two-story Xconfiguration, which would reduce the axial load transferred to the beams. The frameconfiguration in Figure 3-1b depicts a column-link configuration in which the link is adjacent toone of the frame columns. Figure 3-1c depicts a second modifiedchevron configuration inwhich two links are created due to brace-column eccentricity; in this case, one link is consideredactive and one passive. The passive link can introduce uncertainty in the inelastic behavior ofthe frame as the two links do not necessarily equally share the inelastic deformation, as thenomenclature suggests.EBFs successfully combine the high level of ductility of MRFs and the high level ofstiffness of CBFs by introducing eccentricity, between a frames cross bracing and column(Popov & Engelhardt, 1988). The cross brace of an EBF provides the elastic stiffness of CBFand the eccentricity of the cross brace creates a link that isresponsible for the ductility and,therefore, energy dissipation capacity of MRF. The following sections describe the behavior ofthe link of an EBF; all other frame components are intended to remain elastic, and as such,adhere to conventional elastic behaviors.

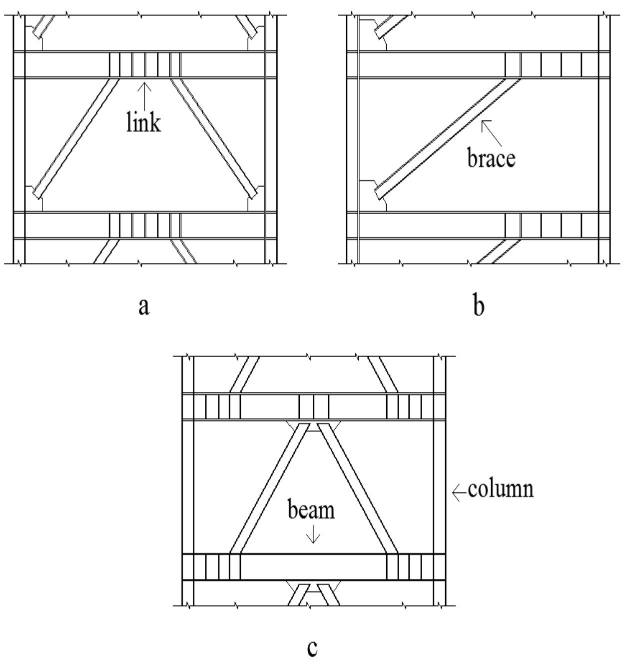

Figure 3-1: Eccentric Brace Frame Configurations

Various code provision for link length is given below

Mode of failure of link	New Zealand Standard 3404	Uniform Building Code 1994	Seismic Provisions for Struc. Steel Building, AISC
Shear Yielding	e <=1.6 M_s/V_s	e<1.3 M_s/V_s (recommended upper limit) e< 1.6 M_s/V_s	e< 1.6 M_s/V_s
Balanced yielding	e= 2 M_s/V_s	e= 2 M_s/V_s	e= 2 M_s/V_s
Flexural Yielding	e > 3 M_s/V_s	e > 3 M_s/V_s	e > 3 M_s/V_s
Link Rotation Angle (radian)	0.09 for e < 1.6 M_s/V_s	0.06	0.08 for e < 1.6 M_s/V_s
	0.045 For e > 3 M_s/V_s		0.02 For e > 3 M_s/V_s

IV. CONSULATION

From the above discussion, it can be concluded that a large number of research studies and buildingcodes have addressed the issue of effects of plan irregularities. Building codes provide criteria toclassify the vertically irregular structures and suggest elastic time history analysis or elastic responsespectrum analysis to obtain the design lateral force distribution. A majority of studies have evaluated theelastic response only. Most of the studies have focused on investigating two types of irregularities: thosein set-back and soft and/or weak first story structures. Conflicting conclusions have been found for theset-back structures; most of the studies, however, agree on the increase in drift demand for the towerportion of the set-back structures. For the soft and weak first story structures, increase in seismic demandhas been observed as compared to the regular structures. For buildings with discontinuous distributions inmass, stiffness, and strength (independently or in combination), the effect of strength irregularity has beenfound to be larger than the effect of stiffness irregularity, and the effect of combined-stiffness-and strength irregularity has been found to be the largest. It has been found that the seismic behavior is influenced by the type of model (i.e., beam hinge model or column hinge model) used in the study. Finally, buildings with a wide range of vertical irregularities that were designed specifically for codebasedlimits on drift, strength and ductility, have exhibited reasonable performances, even though thedesign forces were obtained from the ELF (seismic coefficient) procedures.

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