The 3rd International CUA Graduate Students Symposium

سومین سمپوزیوم بین‌المللی دانشجویان تحصیلات تکمیلی دانشگاه‌های عضو اتحادیهٔ قفقاز

University of Mohaghegh Ardabili

دانشگاه محقق اردبیلی

June 5-6, 2016

16–17 خردادماه

Project-Based According to Functional Knee Braces by Plastic Design

Amin Ghannadiasl
Kazem Shakeri
Nasim Nakhlband saei

Faculty of Engineering, University of Mohaghegh Ardabili, Iran
Faculty of Engineering, University of Mohaghegh Ardabili, Iran
MSc student, Faculty of Engineering, University of Mohaghegh Ardabili, Iran

Abstract
Design is according to a kind of modern methods of structural design. Now days this method have been developed in order to improve the performance of earthquake-resistant structures. Though often design codes use force to analyze for the seismic effects buildings in earthquake. On the other hand deformation and shift control are essential in the design of structures. In this paper, plastic design has been studied on performance form structural steel design with knee bracing system. Therefore, several structures with different heights with knee bracing system against lateral loads according to Iranian Earthquake Design codes and the tenth issue of national building codes is considered as the basic structures. And again based on performance with the methods of plastic design are designed. Basic structures and designed structures are based on the performance under analysis inelastic Pushover. It can be seen that the method of operation under severe earthquakes, create mechanism of surrender purposes, but the method of force the number of plastic hinges are creating in columns. Finally, it can be concluded with design structural based on functional can be taken a new step to improve seismic performance.

Keywords: Functional design, knee braces, deformation of the building

1. Introduction

Earthquake resistant design of structures is one of the most important factors of the modern societies. Scientists studying the destructive effects of past earthquakes on structures are trying to dissolve the deficiencies of the design methods of buildings. The destructive effects and abundant damages caused by major earthquakes during the twentieth century, made the government agents, experts, and engineers to think about a proper solution for confronting this natural phenomenon. Among the new methods for design of structures, performance-based design method can be noted, which is developed today in order to improve the performance of earthquake resistant structures.

The conducted researches during the recent years indicate the superiority of the performance-based design method over the force-based design method. In this paper, the performance-based design method for structures with knee-bracing system is fully explained. The purpose of this study is to evaluate the performance-based design methods against the force-based design methods. Seo and Kim have conducted studies titled seismic design of steel structures with knee braces. Recently, Aristizabal Ochoha has conducted researches on the knee-bracing systems. Naeimi and Bozorg have also studied the seismic performance of knee-bracing systems and Shaban Abdolmohammadi has evaluated the performance-based design method for steel moment resisting frames in a study.

2. Method

1-1- Performance-based design of steel structure with knee-bracing system in this paper is done in such a way that first we consider a structure with 5 stories and a defined plan. This structure has the knee-bracing system in both directions. The structure is considered to be located in Ardabil city and on the soil type II. The structure is a residential and parking building, so is placed in the category of the buildings of medium importance.

1-2- The studied structure is modeled in ETABS 2015 software and is analyzed by using the equivalent static analysis method. The analyzed structure in this step is then again analyzed using the nonlinear static (pushover) analysis method. The aim of this effort is to evaluate the output of the two different methods and to compare them.
Nonlinear static analysis:

1-3- After performing the equivalent static analysis and designing the steel structure members, the preparations for the nonlinear static analysis (pushover analysis) is provided. For this, first we define the nonlinear static load cases in ETABS 2015. We perform the command "Define Menu>Load Cases". In this menu we click the "Add New Case" button and define the nonlinear static load case "PUSHG1" according to Figure (1).
By doing this, the gravity loads are in fact applied to the structure and the nonlinear analysis under seismic loading begins at this final state. After the gravity loads are applied to the structure, the software modifies the stiffness matrix of structure according to the applied gravity loads. The gravity load case "PUSHG2" is also defined according to Figure (2).

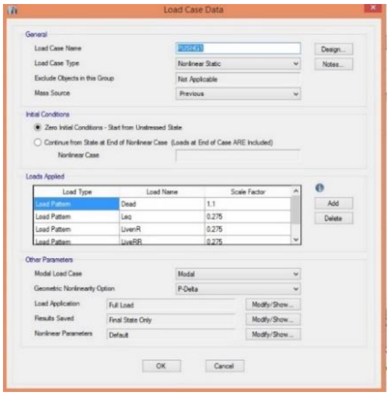


Figure (1): Definition of gravity load PUSHG1

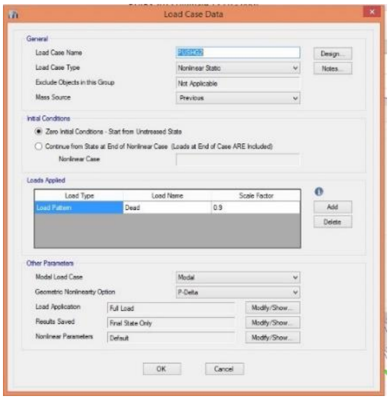


Figure (2): Definition of gravity load PUSHG2

We click the “Modify/Show” button in front of the term “Results Saved” and in the opened box first we choose “Final State Only” and then check the box “Save Positive Displacement Increments Only”. After defining the gravity loads we define the lateral loads. The lateral loads are defined both positive and negative in directions of X and Y following the gravity loads.

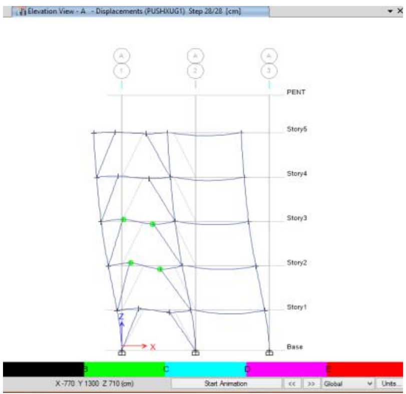
Definition of nonlinear hinge properties:

In order to observe or change the nonlinear hinge properties we perform the command “Define menu>Section Properties>Frame/Wall Nonlinear Hinges…”. Different types of nonlinear hinges can be defined among which axial load, moment of inertia about strong and weak axis, shear in strong and weak axis and the interaction between force and moments are most widely used. After defining the required nonlinear hinge properties in this study, the hinges are assigned to the members. For this purpose, according to the performance and the type of hinge that might be formed in the members, the appropriate nonlinear hinges are assigned to them.

In the present step, in addition to linear static loads the analysis is also performed for nonlinear static loads. The nonlinear analysis is commonly progressed to the destruction of structure, however, different criteria are defined for destruction of structure including the criteria of hinges rupture, the criteria of the mechanism formation and the criteria of nonlinear displacement (deformation) for which an ultimate limit state must be determined in order to limit the amount of displacement. According to the seismic rehabilitation standard of existing structures, this ultimate limit state is equal to the target displacement.

3. Results and Discussion

The results of investigating the story displacements in the equivalent static analysis model shows that the structural drift limitation is not achieved and also the demand to capacity ratio of line members such as beam and column in stories is not suitable, hence, modification of the lateral displacement and strengthening of members are required. In the nonlinear static (pushover) analysis model, as displayed in Figures 4 and 5, with increasing the lateral loading in places in which the hinge occurs in the cross section, the hinge formation sign is appeared.



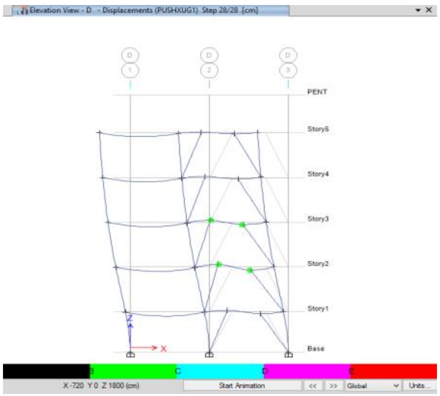


Figure (4): Formation of plastic hinge in frame A   Figure (5): Formation of plastic hinge in frame D

The studied structure meets the target displacement determined based on rehabilitation standard and also the desirable rehabilitation objective.

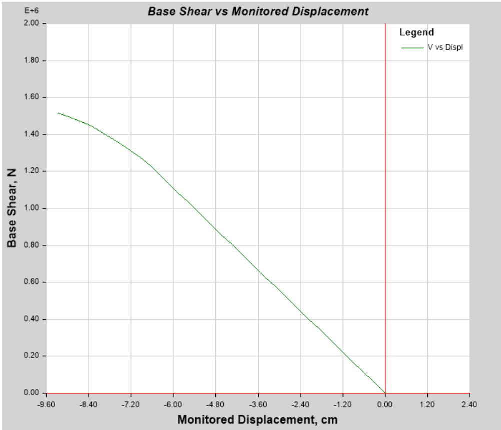


Figure (6): Pushover Curve - Base Shear vs Monitored Displacement

Table(1)

Base Shear vs Monitored Displacement

Step	**Monitored Displ**	**Base Force**	**A-B**	**B-C**	**C-D**	**D-E**	**>E**	**A-IO**	**IO-LS**	**LS-CP**
	cm	**N**								
0	0.002	0	339	0	0	0	0	339	0	0
1	-0.307	57207.9	339	0	0	0	0	339	0	0
2	-0.616	114415.82	339	0	0	0	0	339	0	0
3	-0.926	171623.77	339	0	0	0	0	339	0	0
4	-1.235	228831.76	339	0	0	0	0	339	0	0
5	-1.544	286039.83	339	0	0	0	0	339	0	0
6	-1.854	343247.9	339	0	0	0	0	339	0	0

Step	Monitored Displ	Base Force	A-B	B-C	C-D	D-E	>E	A-IO	IO-LS	LS-CP
	cm	N								
		8								
7	-2.163	400456.24	339	0	0	0	0	339	0	0
8	-2.472	457664.62	339	0	0	0	0	339	0	0
9	-2.782	514873.14	339	0	0	0	0	339	0	0
10	-3.091	572081.83	339	0	0	0	0	339	0	0
11	-3.4	629290.71	339	0	0	0	0	339	0	0
12	-3.71	686499.78	339	0	0	0	0	339	0	0
13	-4.019	743709.07	339	0	0	0	0	339	0	0
14	-4.328	800918.59	339	0	0	0	0	339	0	0
15	-4.638	858128.38	339	0	0	0	0	339	0	0
16	-4.947	915338.43	339	0	0	0	0	339	0	0
17	-5.256	972548.79	339	0	0	0	0	339	0	0
18	-5.566	1029759.45	339	0	0	0	0	339	0	0

Step	Monitored Displ	Base Force	A-B	B-C	C-D	D-E	>E	A-IO	IO-LS	LS-CP
	cm	N								
19	-5.875	1086970.45	339	0	0	0	0	339	0	0
20	-6.184	1144181.8	339	0	0	0	0	339	0	0
21	-6.494	1201393.51	339	0	0	0	0	339	0	0
22	-6.636	1227646.75	338	1	0	0	0	339	0	0
23	-6.951	1279957.75	336	3	0	0	0	339	0	0
24	-7.475	1346793.76	335	4	0	0	0	339	0	0
25	-7.784	1383974.49	335	4	0	0	0	336	3	0
26	-8.359	1449542.17	332	7	0	0	0	335	4	0
27	-8.976	1496216.79	331	8	0	0	0	335	4	0
28	-9.278	1516819.1	331	8	0	0	0	334	5	0

References

1. Jinkoo Kim, Youngill Seo, “Seismic design of steel structures with buckling-restrained knee braces”, Journal of Constructional steel research 59, p.1477-1497, July 2003.
2. Aristizabal-Ochoa, J. D., “Disposable knee bracing: improvement in seismic design of steel frames”, J. Structure. Engineering, ASCE, 1986, 112, (7), 1544-1552

3. Naeemi, M. and Bozorg, M. (2009). Seismic Performance of Knee Braced Frame. World Academy of Science, Engineering and Technology, No. 50, PP. 976-980
4. Shaban Abdolmohammadi, Moein, (1393), "Evaluation of performance-based design of steel moment resisting frames" M.Sc. Thesis, University of Mohaghegh Ardabili, Ardabil.
5. Mousavi, Hashem, Aghaeipour, Tohid, (1393) "Comparison of strength- and performance-based design methods in studying of vulnerability and strengthening of steel buildings" Zanjan university.