STUDY OF THE BEHAVIOR FACTOR OF STEEL STRUCTURES BRACED BY CENTERED BARS

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Abstract- Civil engineering structures are subjected to forces that lead to non-linear behavior under seismic loading, which is particularly the case for metal structures. They absorb the seismic energy transmitted to its resistant elements (columns and diagonals). This ability to dissipate energy by plastic deformation is described by the behavior factor q.
The aim of this study is to evaluate the behavior factor of steel structures braced by centered bars. The structures studied were sized according to the rules and codes in force. They are subjected to vertical loads due to their own weight, and to horizontal loads due to seismic forces introduced by an accelerogram. The software used is the nonlinear analysis program Drain2D, based on the finite element method, where the bar element which plasticizes in tension and buckles elastically in compression, has been introduced. Throughout the study, our main interest is to evaluate the behavior factor, while increasing the intensity of the introduced seismic force.

The results of this present study indicate that the average value of the behavior factor is of the order of q≈3.00. The studied structures were broken by plasticization of these diagonal elements length of this summary may attain twenty lines. Please do not skip lines or insert set back at the beginning of paragraphs.

Keywords: Jacketing, ductility, Rehabilitation, Repair, Strengthening.

1-Introduction

The first concern that the design engineer must have is to provide provisions ensuring the general stability and especially the bracing of all the buildings. The purpose of these requirements is not only to ensure the resistance to the horizontal forces taken into account in calculations, such as those resulting from the action of the earthquake but also to enable buildings to withstand, without undue damage, the effects of certain stresses, such as localized explosions [1, 2, 3]. The damage encountered in structures under seismic loading differs according to the type of bracing chosen [4, 5,6], the metal bracing, reinforced concrete or reinforced masonry cited in seismic code [7,8,9], that is characterized by its coefficient of behaviour, its energy dissipation capacity and its ductility[10,11]. When seismic solicitations are important, the lack of ductility makes the structures vulnerable to rupture. In this work, we study the Steel Structures Braced by Centred Bars while evaluating the value of the behavior factor.

1.1-Definition and Calculation of the Behavior Factor

Under the seismic action, a structure absorbs some energy. The latter is composed of several terms who's namely are: E_e: elastic strain energy, E_{cin} : kinetic energy, Ev: damping energy of structure visco-elastic behavior and Eep: strain energy of hysteresis.

The total energy spent in the structure by the earthquake, will be:

$$E_T = E_e + E_{cin} + E_V + E_{Ep} \qquad (1)$$

To protect structures from this energy dissipated by the earthquake, we use a system of bracing structures.

The role of a bracing is to dissipate the energy transmitted by the seismic action. This quality is described in the literature by a coefficient called of global behaviour factor of the structure. Each calculation code defines it by a name specific to the country of origin. The Algerian paraseismic regulation defines it by the coefficient "R" and Eurocode 8 by the coefficient "q".

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The behavior factor "q" of the structure [3,12,13] is defined by Eq. (2), given below:

$$q_i = \frac{\lambda_{max}}{\lambda_e} \qquad (2)$$

- A multiplier λ_e such that the displacement inter-stages D_e is achieved.
- A multiplier λ_{max} such that the maximum displacement inter-stages D_{max} is reached.

The particular values of each state of the various structures characterized by the behavior factor values and the responses in terms of displacement are defined as to [10, 11, 14]. Thus the value of q corresponding to the intersection on the curve with the bisector Fig. 1 identifies the maximum value of the behaviour factor of the structure.

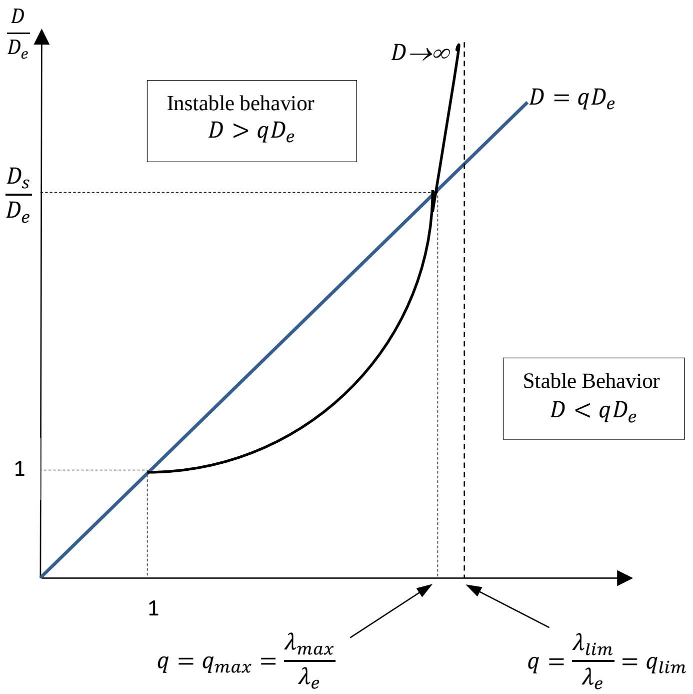

Figure 1: Property of the behavior factor q depending on the ductility.

2- Hypothesis of the Study

2.1- Software used

For these structural applications, the Drain2D structural design program was used. It was developed by A. Kanaan and G.H Powell in the University of California at Berkeley [15]. A linear element which plasticizes in tension and has an elastic buckling in compression was considered in this works.

2.2- Seismic action

The seismic action is defined by the Boumerdes earthquake of 21-05-2003 and El Centro signal records, California 18-05-1940. The El Centro signal has been fully used.

After some analysis, the strain maxima are reached during the period 0 to 5.10 seconds, which corresponds to the strongest accelerations [5,9].

2.3- Structures studied

The studied bracing elements are that of plane steel constructions, of which views in plane and elevations are, illustrated in Fig.2 and Fig. 3 respectively.

There number of levels ranges from three to six. The structures designs and the mechanical characteristics are fixed in accordance with Eurocode 3 and Eurocode 8 [7, 8, 16].

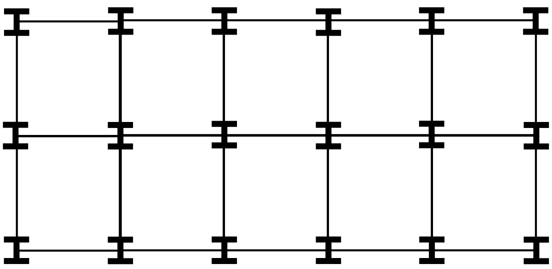

Figure 2: Plane view of the studied structure

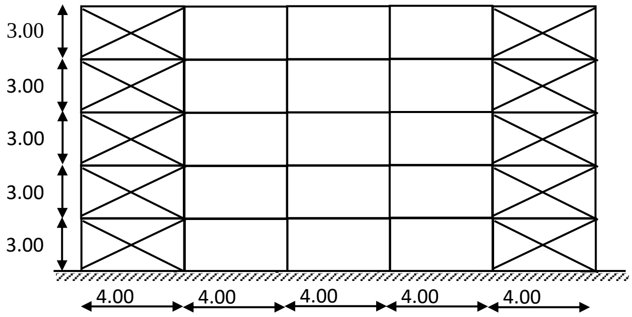

Figure 3: Elevated view of the studied structures for a 5 number of level

We retained the following sections for all structures in order to draw conclusions Tab.1.

Table 1: Structural elements

	STR 1	STR 2	STR 3	STR 4
Columns	HEA 240	HEA 240	HEA 240	HEA 240
Beams	IPE 240	IPE 240	IPE 240	IPE 240
Diagonals	80x80x8	80x80x8	80x80x8	80x80x8

The steel *fy* yield strength is equal to 235 N/mm^2.

The structures are also subjected to vertical loads, as specified for residential buildings by the standards, resulting in a permanent load *G* and a variable load *Q* [8,9].

3- Results of the Study and discussion

The structures are excited by the accelerogram El Centro until obtaining the elastic limit state for each case. Indeed this operation runs until obtaining the ultimate limit state of each structure. The values of the behavior factor are given in Table 2 for each structure.

Table 2: Overall displacement, overall ductility as a function of behavior factor q

STR	q	D (mm)		$\frac{D}{D_e}$	
		+	-	+	-
STR 1	1	13	14	1.00	1.00
	2	26	20	2.00	1.43
	3	49	21	3.77	1.50
	4	59	31	4.54	2.21
	5	120	49	9.23	3.50
	6	173	109	13.30	7.78
	7	133	178	10.23	12.71
	8	148	263	11.38	18.76
STR 2	1	15	18	1.00	1.00
	2	20	31	1.33	1.72
	3	72	30	4.80	1.66
	4	170	23	11.33	1.27
	5	217	55	14.46	3.05
	6	158	146	10.53	8.10
STR 3	1	19	23	1.00	1.00
	2	27	47	1.42	2.04
	3	51	45	3.68	1.95
	4	98	28	5.15	1.21
STR4	1	21	26	1.00	1.00
	2	44	26	2.10	1.00
	3	43	45	2.04	1.73
	4	31	64	1.47	2.46
	5	37	104	1.67	4.02

Behavior factor q values based on the ductility Di/De of our studied structures are represented by Fig. 4 for each structure.

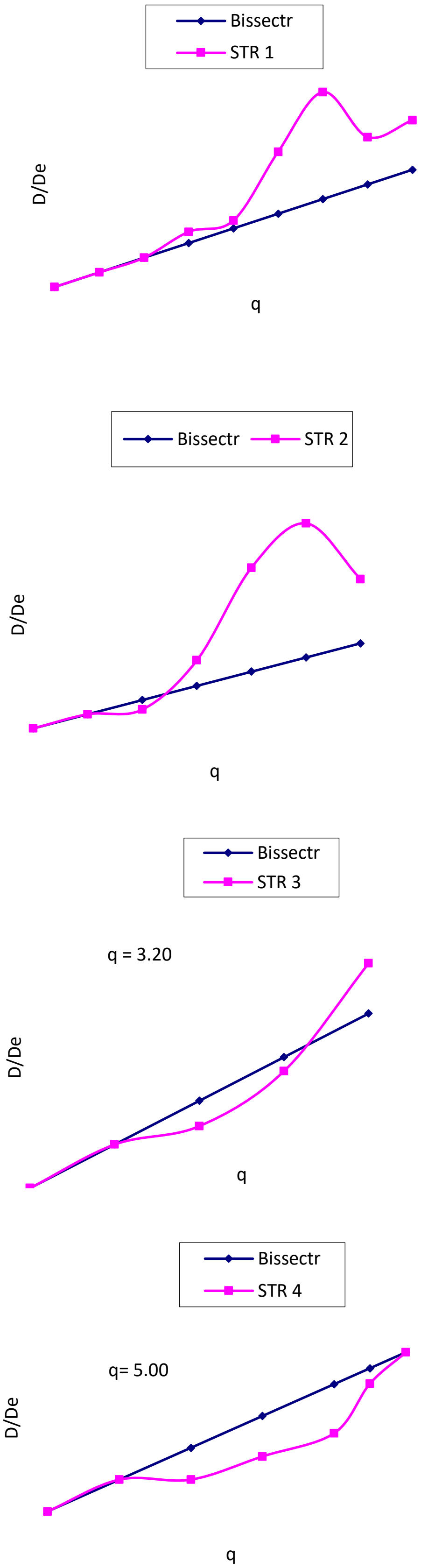

Figure 4: Behavior factor based on the global ductility for the structures

The average value of the behaviour factor is of the order of q≈2.00 for the structures a three and four levels. But, for the structures of five and six levels, the value of the behaviour factor is in average of q≈4.00. This value is comparable to that given in the literature and the main research established by the European Union is recorded in Eurocode 8 [12, 14, 17]. The studied structures were broken by plasticization of these diagonal elements.

4- Conclusion

This work is based to the numerical study of the behavior factor for steel frames structures with the centered bracing under seismic loading. The analysis is achieved for structures with three to six levels using the non linear dynamic analysis Drain-2D program developed at Berkeley University which constitutes an interesting tool for evaluating the behavior factor for steel constructions. We have kept the same height sections for all structures. On the other hand, we introduced a mass irregularity on the top floor (terrace) to take reality into account.

As a result, the value of the behavior factor obtained steel frames structures with the centered bracing are of the order of 3.00. The study showed that we are within the range recommended by Eurocode-8 in accordance with an average level of ductility.

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