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The Effect of Centric Steel Braced Frames with High Ductility Level on the Performance of Steel Structures

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Abstract

The basic functions expected from any structure are generally sufficient rigidity, ductility and stiffness. In this study, the effect of steel ducts with high ductility level on the performance of steel structures was investigated. For this purpose, calculations were made using five different types of central steel curtains for steel flues of any hospital building. Period, frequency, modal addition rates, displacement and rotation values are calculated and compared for each different central steel screen. The aim of the study is to be informed about the central steel slabs with high ductility level and to have information about which of the most suitable central steel slabs will be chosen.

Keywords: Ductility, High Ductility, Steel Structures, Performance, Steel Cross Braced Frame

Süneklik Düzeyi Yüksek Merkezi Çelik Perdelerin Çelik Yapıların Performansına Etkisi

Özet

Herhangi bir yapıdan beklenen temel işlevler genel olarak yeterli rijitlik, süneklik ve dayanımdır. Bu çalışmada süneklik düzeyi yüksek merkezi çelik perdelerin çelik yapıların performansına etkisi incelenmiştir. Bu amaçla herhangi bir hastane binasına ait çelik baca için beş farklı merkezi çelik perde çeşidi kullanılarak hesaplamalar yapılmıştır. Her bir farklı merkezi çelik perde için periyot, frekans, modal katkı oranları, yer değiştirme ve dönme değerleri hesaplanarak karşılaştırmalar yapılmıştır. Çalışmadaki amaç süneklik düzeyi yüksek merkezi çelik perdeler hakkında bilgi verilerek en uygun merkezi çelik perdenin hangisinin seçileceği hususunda bilgi sahibi olmaktır.

AnahtarKelimeler: Süneklik, Süneklik Düzeyi Yüksek, Çelik Yapılar, Performans, Çelik Perde

1. Introduction

Rigidity, ductility and strength must be sufficient to ensure that the earthquake loads are transmitted continuously and safely to the foundation of the earthquake loads as well as in each of the elements constituting the earthquake loads at the same time [1]. Adequate rigidity, strength and ductility are at the top of the principles considered in the design of earthquake-affected structures. In the regulation of the structural bearing system, the material strength, the ductility and stiffness concepts in the elements are important parameters [2]. These parameters need to be built into the structure.

Generally, ductile conveying systems are the foreground in the depressive structure design. However, it is emphasized that the selection of the regular carrier system in the horizontal and vertical sections and the encouragement to be shown in the junctions of the elements.

Ductility is defined as the extent of displacement of a section, of an element or of a carrier system, without significant change in external load, beyond the elastic limit, and the system ductility rate is proportional to the linear shape changes of the total shape changes in the displacement order. The result of the system ductility ratio taking large values ensures that the structure can change its nonlinear shape sufficiently before migration.

Central crossed structures are very popular for medium height structures. Design and production are simple and the required horizontal stiffness and strength can be obtained with low cost. The horizontal stiffness of the central steel cross curtains is provided by vertically positioned cage beams. This lattice behaviour is obtained by crossing the column and the beams [3, 4, 5].

In this study, calculations were made in the case of using five different centric steel braced frames for a steel chimney belonging to a structure designed as a hospital building. The results were compared and recommendations were made.

2. Materials and Methods

Structural engineering is the science and art of designing and making, with elegance and economy, buildings, bridges, frameworks and other similar structures so that they can safely resist the forces to which they may be subjected [6]. The main purpose of structural design is to produce suitable structure. We must consider not only the initial cost, but also the cost of maintenance, damage and failure. Thus, the optimum design of a structure requires a general view on the total process [7].

The design of steel seismic resistant structures took a dramatic turn after the last Californian and Japanese events. The heavy damage observed as a result of these earthquakes was never before recorded in the history of building design. These events gave rise to a general effort all over the world to improve the seismic resistance of steel structures. A comprehensive program started to evaluate both the design specifications and detail rules. In this perspective, clear attention has been paid to the evaluation of local ductility erosion at the level of sections [2].

Ductility is a measure of the ability of a section, an element, or a carrier system to deform beyond the elastic limit, without significant change in external load. The numerical definition of the system ductility ratio is the ratio of the total shape change to the linear shape change during the displacement.

The two most important features of steel are energy absorption capacity under ductility and repeated inelastic loading. In terms of behavior against depression, horizontal load carrier systems of steel buildings are separated into two classes in terms of ductility level [2].

In Turkish Seismic Code, TEC-2007, based on their behaviour against seismic events, the lateral load bearing systems of the steel constructions are classified in two sections based on their ductility.

a. *Systems with High Ductility*
b. *Systems with Low Ductility*

based on this, the classifications are further divided to

• Frames with High Ductility,
• Shears with Steel Cross Beam Bars with High Ductility,
• Shears with Outer Steel Cross Beam Bars with High Ductility,
• Frames with Standard Ductility" and
• Shears with Steel Cross Beam Bars with Standard Ductility,

to form a list with five different titles with descriptions in seismic activity regulations.

In this study, centric steel braced frames with high ductility level are shown in Figure 1. The lateral load carrying capacity of these systems is large, along with their bending strength. Obviously, these shear wall systems can be interpreted as earthquake walls in a reinforced concrete structure.

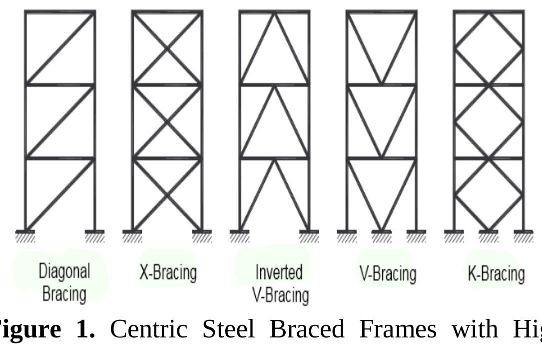

Figure 1. Centric Steel Braced Frames with High Ductility

As a numerical application, a steel chimney of hospital structure was analyzed. In the project, the steel chimney was transferred to the rectangular truss system. The steel chimney has an area of 3,125 m^2 and a span of 2.5 m. The building height is 12 m. 150 * 150 * 5 mm was used for the structural system columns and 60 * 60 * 4 mm box profiles were used for the beams and bracing members (Figure 2).

Fe37 steel was used as material. In Fe37 steel σ_{saf} = 14.1 kN /cm^2, σ_{yield} = 24 kN /cm^2, σ_{weld} = 11 kN/cm^2 were taken.

In calculations, truss span L = 2,50 m, truss space L' = 1,25 m and number of truss were two.

The wind load is taken as q = 0.8 kN /m^2 from TS498 Specification [8].

The steel chimney was modelled and analyzed in the SAP2000 package program [8]. It is modelled as a 12-storey structure while modelling a 12 m high chimney system. Five different centric steel braced frames were used in this study. Centric steel braced frame types considered in the study are taken from the SAP2000 program and shown in Figure 3.

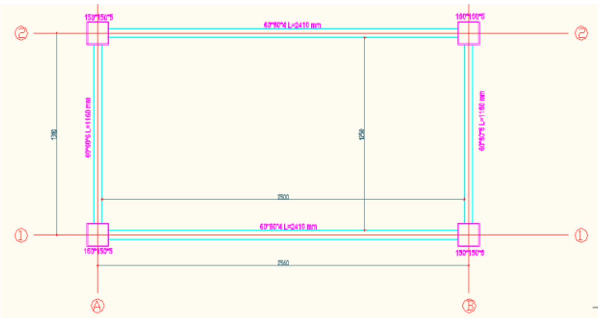

Figure 2. Steel Chimney Plan

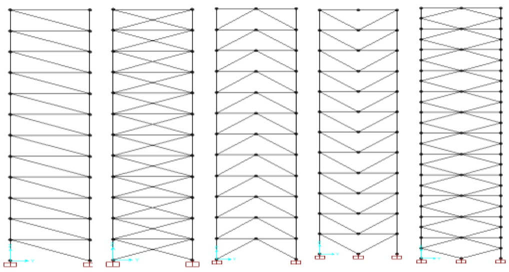

Figure 3. SAP2000 model of Centric Steel Braced Frames

In the dynamic analysis of the chimney system, the seismic parameters and function values shown in Figure 4 are entered. Period, frequency and eigen values are calculated for each braced type with these values.

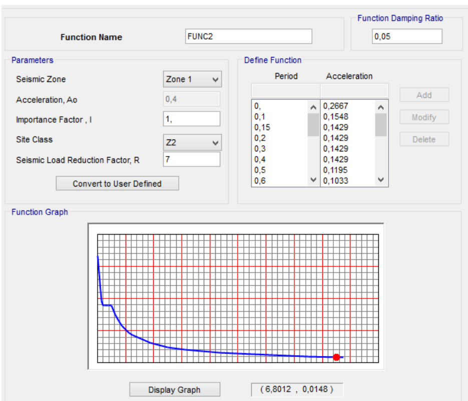

Figure 4. Seismic parameters in SAP2000 program

The displacements and rotations calculated in the SAP2000 program for the five different steel braced frames given in Figure 3 above are presented in Table 1.

Table 1. Displacements and rotations of centric steel braced frames

	Displacements [mm]			Rotations [rad]		
Frame Type	U_X	U_Y	U_Z	R_X	R_Y	R_Z
Diagonal Bracing	10,40	-0,10	-0,70	0,00000	0,00095	-0,00013
X-Bracing	8,90	0,27	-0,70	0,00000	0,00090	-0,00010
Inverted V-Bracing	8,20	0,00	-0,50	0,00000	0,00082	0,00000
V-Bracing	10,70	0,00	-0,70	0,00000	0,00100	0,00000
K-Bracing	8,90	0,00	0,60	0,00000	0,00090	0,00000

3. Results

In this study, the effects of five frames with high ductility level centric steel braced frames were investigated. Horizontal displacement values occurring in the building under lateral loads (earthquake and wind loads) are given in Table 1. The limitation given by the specifications is provided with confidence. That is, the frame with high ductility level centric steel braced frames is provided with a rigidity of about four times.

As shown in Table 1, the maximum lateral displacement is calculated as u_x = 10.7 mm at the top of the steel chimney. In the specifications, displacement is generally given as $u_x \leq \Delta_{max}$ = H/300 limit. From here, if the constraint is checked, u_x = 10.7 mm $\leq \Delta_{max}$ =12000/300 = 40 mm will be seen. H/300 limit. From here, if the constraint is checked, u_x = 10.7 mm $\leq \Delta_{max}$ =12000/300 = 40 mm will be seen.

Nearly the same performance was achieved with five types of centric steel braced frames applied to lateral displacements.

With the classic Moment-resisting frames, larger lateral displacements are obtained and displacement limits cannot be achieved.

Finally, it is concluded that the systems providing the best limitations for earthquake performance and specifications are high ductility level centric steel braced frames.

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