Journal of Civil Engineering Researchers

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JOURNAL OF CIVIL ENGINEERING RESEARCHERS

The effect of the height-to-frame ratio in the cyclic behavior and curve of the frame capacity of a single crater

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Abstract

Many of constructional structures are designed in a way that at least go under the pressure of relatively intense loads once in the construct's lifespan. Along with the progress of earthquake engineering science and emphasis on construct retrofitting against lateral forces, using appropriate systems and safe performance against these forces is needed. Today, all structural engineering science researchers are trying to make a leap forward this scope with studying different kinds of systems. In the science of dynamic of construct, system with one degree of freedom and one crater which includes one flat frame is baseline for starting investigations and calculations. In this article, one metal frame with different ratios of height-to-crater's length under lateral concentrated force in the ceiling's balance and also under cyclic loading is placed and performance of this frame in different states in the form of a capacity and Hysteresis curve is investigated. ANSYS software was used for modeling of proposed models and the results were compared with each other.

Keywords: one crater frame, Hysteresis curve, nonlinear behavior, capacity curve, plasticity

1. Introduction

Based on the characteristics that metal constructs have, using them in various constructional and non-structural structures is common. In particular, steel's high resistance makes it a more usable material for designers relative to other structural materials including concrete. In the most engineering structures, having information about the moment of structure's collapse is very vital, because if applied load to the structure is known, structure could be judged easily. In the investigation of nonlinear behavior of materials in the science of plasticity, different criterions have been proposed for expressing

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material's behavior which mainly has been presented in *ANSYS* software. Metal frames have limited capacity and if the amount of movement and force breaks the threshold, structure will be collapsed. The purpose of this article in one step is investigation of cyclic behavior of frames under back and forth loading and in the other step is finding frame's load and movement in the moment of collapse in different states of dimensions and height-to-length ration.

2. Defining the issue

In this investigation, effect of dimensions of one flat metal frame and one crater under back and forth loading and lateral concentrated force will be investigated. For this purpose, numerical analysis using *ANSYS* limited components software on the different models will be conducted. In the first step, frame goes under the lateral cyclic loading in four different states and Hysteresis curve will be extracted from them. In the next step, each of frames are placed in the balance of shaft under lateral concentrated force and results including frame's capacity curve (force-movement) and also transformation made in the frame will be achieved. Results of interpretation of capacity and Hysteresis curve are indicators of frame's performance. The more area under curves or number of back and forth cycles in the Hysteresis curve means that structure is more tolerance against applied force and has better performance.

3. Modeling

Modeling and analysis of frames was conducted in the *ANSYS* limited components software. Desired frames are considered under different circumstances of height-to-length of crater as it has shown in the figure 1 and table 1. applied concentrated force to the frames is 300 kilo Newton.

Table 1-geometric characteristics of frames

Row	Length of crater (meter)	Height (meter)	Height-to-length of crater ration
1	6	3	0.5
2	6	6	1
3	6	9	1.5

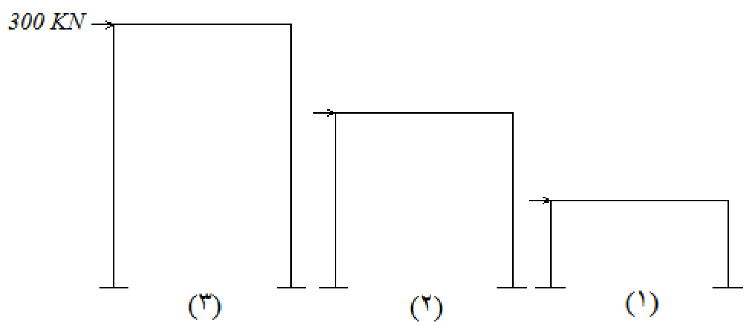

Figure 1. different circumstances of height-to-length of crater in frames

Cross section of frame's members for all shafts and bars is considered equally. This section is in the shape of squared can. External side is 16 centimeters and thickness is 8 millimeters. Mentioned characteristics for materials of the structure have given in table 2.

Table 2- Material characteristics

Modulus of elasticity (E)	Poisson ratio (ν)	Surrender tension (σ_y)	Rupture tension (σ_u)	Surrender strain (ε_y)	rupture Strain (ε_u)
$2\times10^{11}\,N/m^2$	0.3	240	376	0.0012	0.02

For consideration of nonlinear behavior of steel, tension and strain curve of steel is measured bilinear which the second sloop equals 10% of primary sloop line $0.1E = 2\times10^{10}\,N/m^2$

For back and forth loading, alternate switching applied to the frames is shown in figure 2.

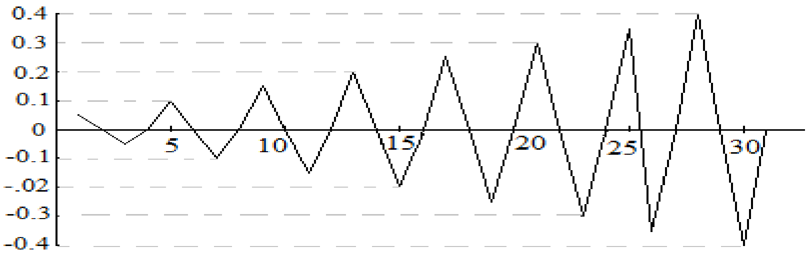

Figure 2. Applied movement to the frames

4. Models' analysis

After models' analysis, software output will be extracted in the form of different diagrams and shapes which is shown in figures 3 to 8. These diagrams include maximum cutting base against maximum shift of shafts' balance.

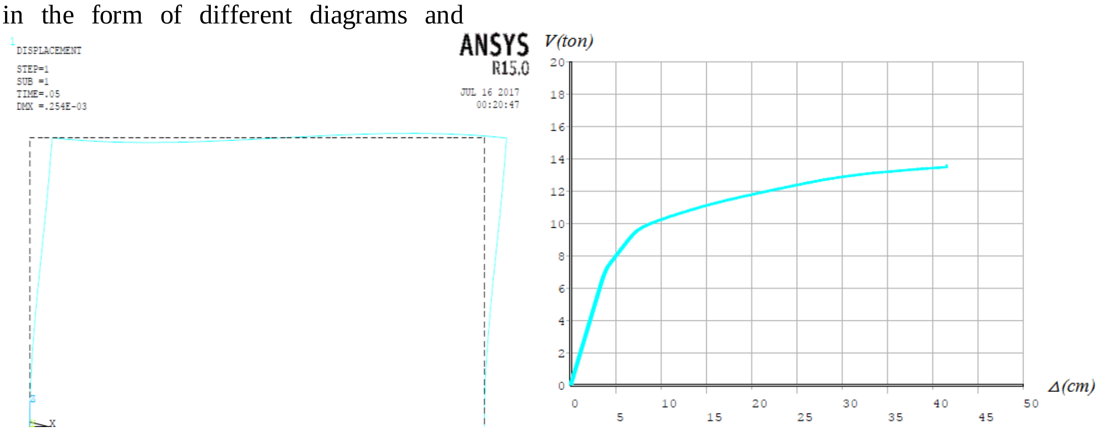

Figure 3- capacity curve and exhibition of frame number 1's movement

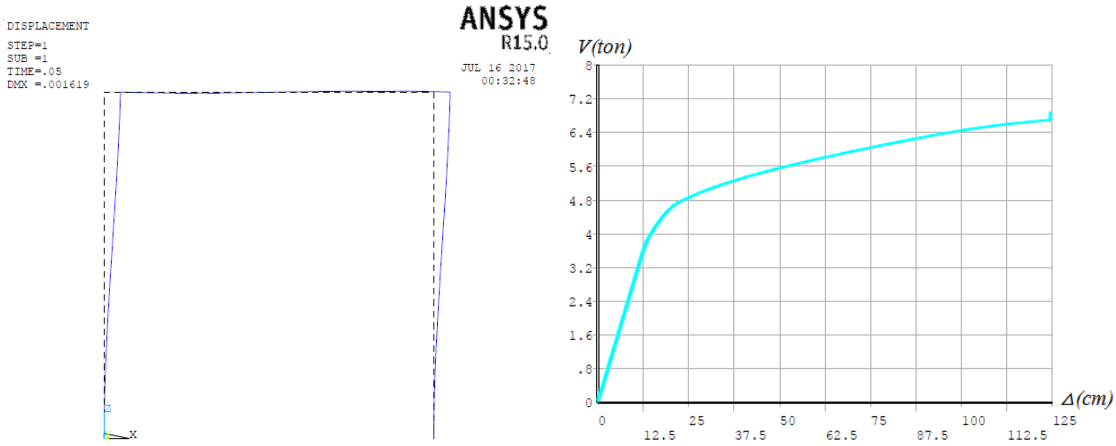

Figure 4- capacity curve and exhibition of frame number 2’s movement

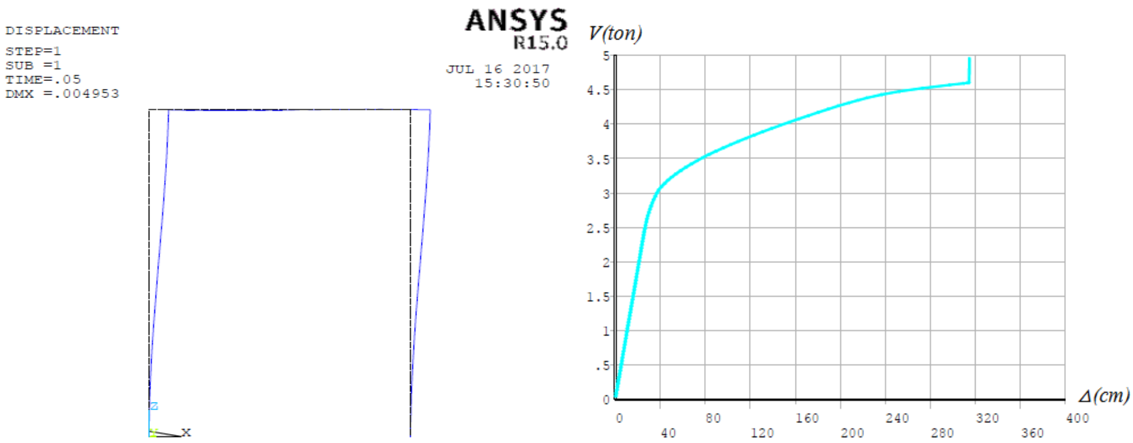

Figure 5- capacity curve and exhibition of frame number 3’s movement

Results are shown in table 3.

Table 3. maximum cutting base and maximum shift of shafts’ balance

row	$\Delta_{max}\,(cm)$	$V_{max}\,(ton)$
1	41.55	13.62
2	124.38	6.89
3	314.62	4.96

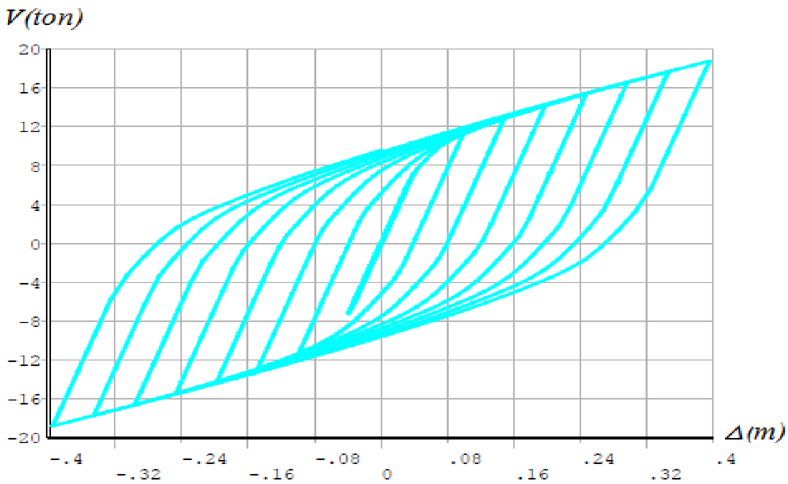

Figure 4- Hysteresis curve of frame number 1 under back and forth loading with the maximum of 40 centimeters

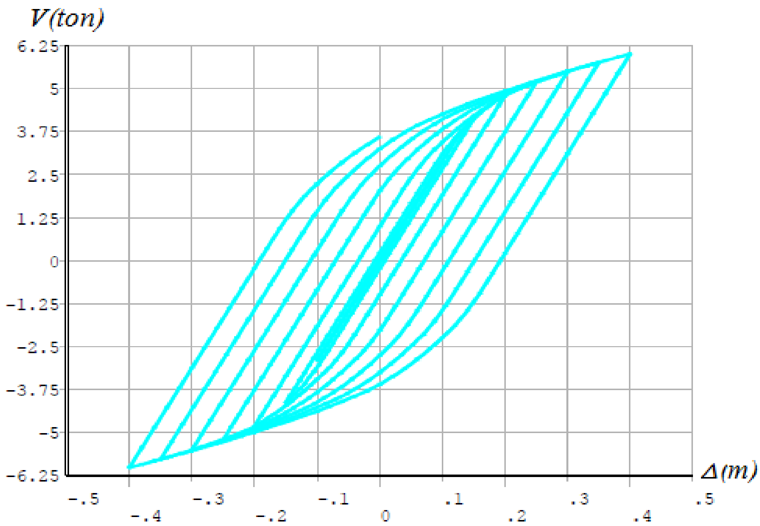

Figure 5- Hysteresis curve of frame number 2 under back and forth loading with the maximum of 40 centimeters

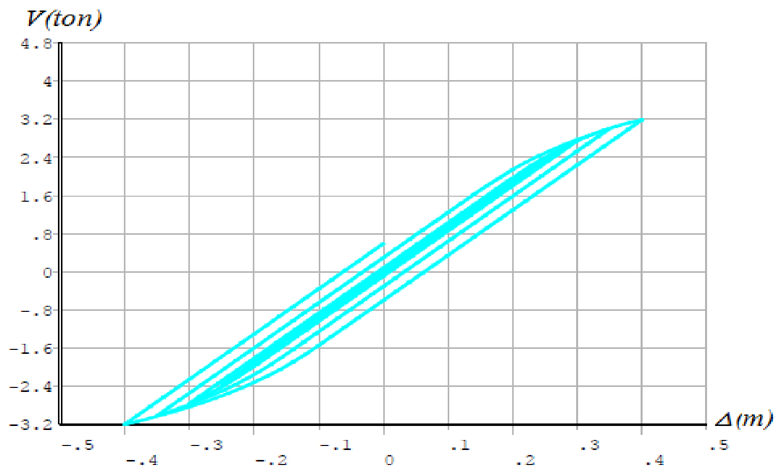

Figure 6- Hysteresis curve of frame number 3 under back and forth loading with the maximum of 40 centimeters

5. Conclusion

Based on the achieved shapes from software's analysis, these conclusions will be derived:

1. Maximum of tolerable capacity in the desired structure observes in state 1. In this state height-to-length of crater ration has the lowest value. Furthermore, capacity of structure tolerance has opposite relationship with height.
2. Appropriate Hysteresis curve has three characteristics: symmetry, number of back and forth cycles and high lever under curve. Based on the achieved curves, state 1 has the best performance in the cyclic loading.

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