Advanced Materials Research Vols. 243-249 (2011) pp 5845-5848
Online available since 2011/May/17 at www.scientific.net

doi:10.4028/www.scientific.net/AMR.243-249.5845

Strain rate effect on transmission tower-line system under earthquake action

Wenming Wang[1, a], Hongnan Li[1, b], Guohuan Liu[2, c], Li Tian[1, d]

[1]Faculty of Infrastructure Engineering, Dalian University of Technology, Dalian, Liaoning, 116024, China

[2]Department of Civil Engineering, Tsinghua University, Beijing, 100084, China

[a]wangwenming87110@163.com, [b]hnli@dlut.edu.cn, [c]carecivil@sina.com, [d]tianl-007@163.com

Keywords: transmission tower-line system, nonlinear time-history analysis, strain rate effect, earthquake.

Abstract. Using ABAQUS software, three dimensional finite element model of a transmission tower-line system is created. Nonlinear seismic responses under three seismic records with and without strain rate effect are studied. The results show that the strain rate effect on the transmission tower-line system is more obvious with an increase in intensity of the earthquake. The influence of strain rate on the top displacement and base shear of tower under certain seismic records is unneglectable. Also, it is shown that the strain rate effect on the deformation of wire is prominent. The strain rate effect on the axial force of wire is neglectable. This simple study reveals the importance of considering strain rate effect in seismic analysis for transmission tower-line system.

Introduction

Most materials used in civil engineering are sensitive to strain rate. At different strain rate, the mechanical properties of steel including strength, stiffness and ductility are different [1-4]. Therefore, strain rate effect should be considered in seismic analysis.

Electric transmission line is lifeline system whose damage can cause great economiclose and bring certain social influence because of its special functions [5]. In the past decades, the study concentrated on static analysis, mode analysis and dynamic time-history analysis without considering material nonlinearity [5-7]. Under catastrophic earthquakes, transmission tower-line system might be damaged, and then it is necessary to consider material nonlinearity. The strain rate effect on transmission tower-line system is studied by nonlinear time-history analysis of a model using ABAQUS in this paper.

Strain rate effect

Strain rate effect of material. As early as the mid twentieth century, Zener and co-worker studied the strain rate effect of steel [1]. As the improvement of testing method and testing equipment, the recent experiment results are more reliable. In the past decades, many scholars did lots of dynamic loading experiments of steels including HPB235, HRB335, HRB400 and so on [2-4]. The results show that: Different steels have different sensitivity to strain rate; the yield strength and tensile strength increase with the increase of strain rate, and the yield strength is more sensitive to strain rate than the tensile strength; generally, the lower the yield strength is, the more obvious of the sensitivity is; the elastic module is almost invariable with the increase of strain rate.

In earthquake, the strain rate of steel is hard to exceed 1/s. The dynamic constitutive relationship model incorporated in the finite element analysis is as follows [4]:

$$f_{yd} = (1 + c_f \lg \frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}) f_{ys} \quad (1)$$