

## Analysing and Comparing the Behaviours of Cylindrical Fatigue Specimens Made of Ni-Ti Shape Memory Alloy and Steel

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**Abstract** - The frequency and the dynamic harmonic behaviours were analysed by using the cylindrical fatigue specimens. The two types of materials were used in the cylindrical fatigue specimens were Steel and Nickel-Titanium shape memory alloy. The same type of loading and boundary conditions were given to the both of the specimens and various behaviours were compared using Abaqus. Relative scaling of full cycle was given in the scale factor/harmonic and modal frequencies of different deformations were analysed by selecting the range up to particular modes (i.e. up to 20) and Steady state dynamic analysis was also done in specimens. Ni-Ti alloys were implemented to control the vibrations in the structures. Due to their advantages like high corrosion resistant than steel, vibration control, shape memory alloys were used in place of steel in many construction related applications, especially in tall buildings.

**Key Words:** Abaqus 6.14, Finite element method, Ni-Ti shape memory alloy, Steel, Cylindrical fatigue specimens.

### 1.INTRODUCTION

A cylindrical fatigue specimen consists of two shoulders and a gauge section. In between these two shoulders, the gauge section is placed. The some of the shoulder is very large when comparing with the gauge zone. Due to this larger cross sectional some of shoulders and very minimum cross section of the gauge zone. The large amount of deformation or failure is expected in the gauge zone. Due to the variation of grips in the testing machine, the manufacturing of the shoulders in the test specimen is specifically concentrated. The main two types of grips are serrated grips and pinned grips. The shoulders which are manufacturing for the serrated grips are easy and the cost for the manufacturing of these types of shoulders is low and this alignment depends upon the technician's skill. The pinned grips should make good and fine alignment. Threaded shoulders and grips make good and fine alignment. For handling this, the technician should know how to thread each shoulder in to the grip or else there is more possibility of thread in slip. In this paper round shoulders were taken to check various behaviours. For this, the material of the specimen is taken as shape memory alloy (Nickel-Titanium). The fatigue behavior of D2125 super alloy was taken to check the effect of the

frequency and sample shape. The ultra-high cycle fatigue property of turbine blade made of D2125 super alloy in aero engine Fr 20-400 was studied based on the ultrasonic fatigue test system. In this both the cylindrical specimens and plate specimens were taken for the ultra-high cycle fatigue testing. S-N curves were being drawn to check the life [1]. A263 magnesium alloy was taken for the investigation on bonded environment. In this the applied frequencies were 1 and 10 Hz. These investigations were done with 50C-80%R08 environment; investigation is also based on the effect of frequency on fatigue crack growth [2]. The phase transformation was first recorded in Cold-Cadmium alloy. After that many researchers found that the Nickel-Titanium alloys behave well in phase transformations, they are better in the electrical and thermo mechanical characters. Ni-Ti shape memory alloys are used in heating in columns, heat insulation, connectors in steel structures. In some cases these SMA is also used as the reinforcements [3]. Some different types of SMAs are evaluated based on their mechanical and durability properties. Among them, Ni-Ti is used in vibration control of structures. This is due to its super elastic behavior, good fatigue and corrosion resistance and great durability. In general, damping capacity of a member largely depends on the larger area of the hysteresis loop. By using SMA, we can obtain large area of hysteresis loop [4]. Piezoelectric, magnetostrictive, photochromic and thermochromic, electrostrictive, thermoelectric, shape memory alloys were the various classifications in smart materials. Smart materials were the materials in which they are having the capability to change their characters by giving external stimuli to it. Ni-Ti alloys were having extraordinary super elastic and shape memory behaviours [5]. Shape memory alloys were also used in retrofitting in structures. Best example was the retrofitting of the bell tower of the Church of San Giorgio in Trignano, Italy. The magnitude of 4.8 M earthquake resulted in major damage in the bell tower. Following the earthquake, the tower was rehabilitated by using SMA. The SMA damper was found to be more effective in the moment-resisting form than the cast-in-place form [6]. The torsion and rotating bending fatigue endurance was investigated. For that, the specimen is made as aluminum alloy. The tests for torsion fatigue were conducted at load ratio  $R = 0$  and frequency of 10 Hz, the tests for rotating bending fatigue were conducted at load ratio of  $R = 1$  and the frequency of 50Hz. Fatigue endurance under the rotating bending is hundred times higher than torsion fatigue

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