Friction Pendulum System- A Parametric Study of Friction Coefficient

Tessy Thomas
PG Student
Department of Civil Engineering
Mar Athanasius College of Engineering
Kerala

Alice Mathai
Associate Professor
Department of Civil Engineering
Mar Athanasius College of Engineering
Kerala

Abstract

Damage to buildings during an earthquake can be prevented or reduced by base isolation technique in which isolators are installed beneath the structure. Friction Pendulum System (FPS) is a one type of sliding isolation systems consists of steel bearing with spherical sliding surface and slider. The lateral stiffness is provided by spherical surfaces of the FPS and the energy is dissipated by the friction provided in the contact surface. The restoring force equal to the tangential component of the vertical load on the bearing is given by the curvature of the sliding surface. These isolators are designed to be very stiff and strong so that they can carry the weight of the building and protect from strong shakes. When earthquake occurred, the bearing decouples the structure and reduces the force transmitted to the superstructure. In this paper, the model of the isolator is analysed using ANSYS software to study the behaviour of the isolator. A parametric study dealing with the coefficient of friction using nonlinear static analysis is done and the results are interpreted.

Keywords: Concave Surface, Friction Coefficient, Friction Pendulum System, Nonlinear Static Analysis, Seismic Isolators

I. INTRODUCTION

SEISMIC isolation which decouples the structure from ground is widely accepted protection systems against the seismic risk. During earthquakes, the strong shakes is not transferred to the building, relative drift for isolated building will be less, so the entire building thus protected. In recent times, several base isolators are used in earthquake prone area; one type of sliding bearing isolators is Friction pendulum system (FPS). Friction pendulum system is consists of two horizontal steel plates that can slide over each other because of their shape and an additional articulated slider. The bearings are positioned between the bottom of a building and its foundation. The radius of curvature is controlling the period of motion. The curvature of the sliding surface and a small part of the friction contribute the lateral stiffness of the bearing. Friction at the contact surface between the sliding surface and slider largely account for effective damping. This system can accommodate large displacements and large vertical loads, also provide horizontal stiffness. The fig. 1 shows the friction pendulum system.

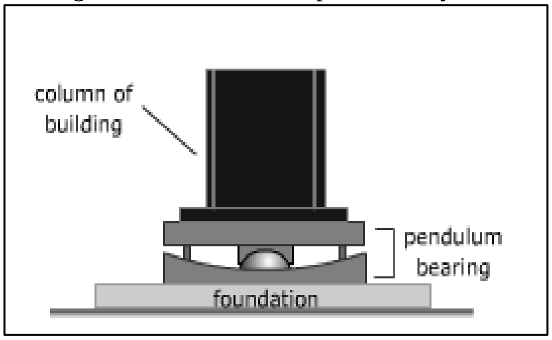

Fig. 1: Friction pendulum system (FPS)

II. MODELLING OF FPS

A three dimensional model of the base isolator is created using ANSYS software. SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior is used for the modeling of the base isolator. The contact properties between the slider and the sliding surface are assigned by contact elements. A 30 storeyed building with radius of curvature of 2235mm and the horizontal displacement of 200mm by nonlinear static analysis are taken for the model. The base isolator was studied with the following coefficient of friction value 0.02, 0.04, 0.06, 0.08 and 0.1 the results of each case are discussed below. The fig. 2 shows model of the isolator. The fig. 3 and 4 shows the stress intensity diagram for coefficient of friction 0.02 and 0.1

are given below. The fig. 5 and 6 shows the von Mises stress diagram for coefficient of friction 0.02 and 0.1. The fig. 7 and fig. 8 shows friction coefficient Vs stress intensity graph and friction coefficient Vs von Mises stress graph respectively.

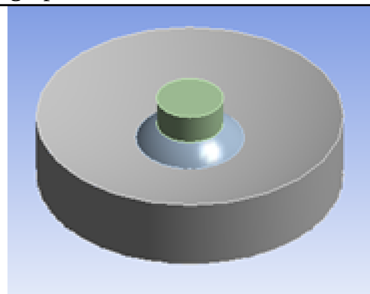

Fig. 2 Modeling in ANSYS

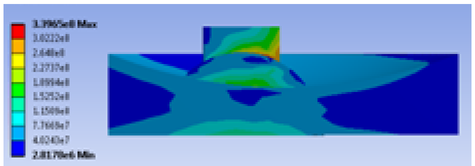

Fig. 3 Stress intensity for 0.02

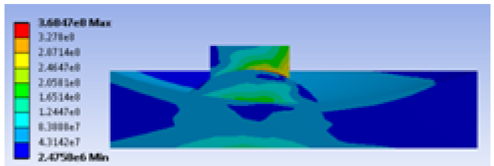

Fig. 4 Stress intensity for 0.1

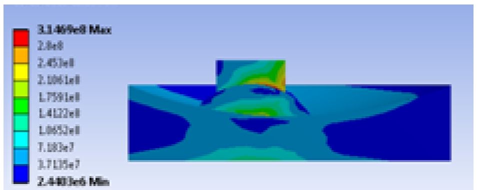

Fig. 5 von Mises stress for 0.02

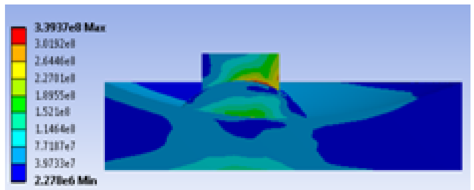

Fig. 6 von Mises stress for 0.1

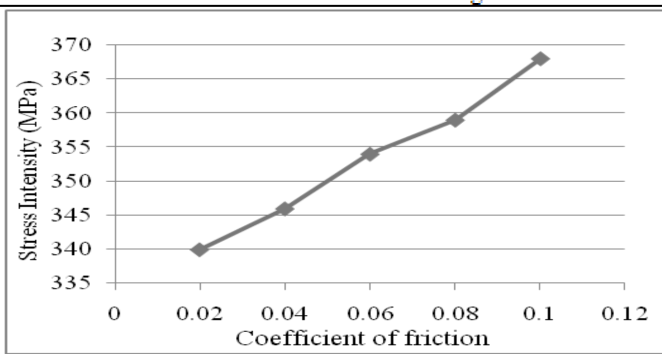

Fig. 7: Friction coefficient Vs stress intensity

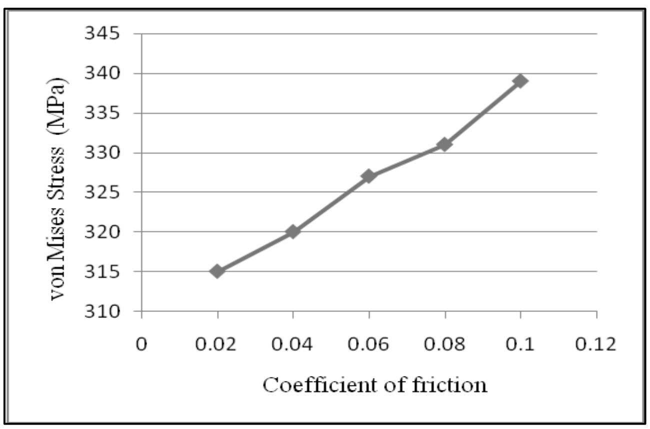

Fig. 8: Friction coefficient Vs von Mises stress

The base isolator with varying coefficient of friction by keeping constant radius of curvature, compressive load and horizontal displacement is analysed. The graph with coefficient of friction versus stress intensity shows as coefficient of friction value increases, the stress intensity value of the isolator increases. And also from coefficient of friction versus von Mises stress graph, as coefficient of friction value increases the von Mises stress value of the isolator also increases. From stress intensity diagram and von Mises stress diagram stress value is dominant at the contact surface of top plate due to the compressive load and the horizontal displacement. And when horizontal displacement increases, the slider moves along the concave surface of the isolator with the damping effect of friction properties in contact area.

III. CONCLUSION

The three dimensional model of the isolator is created and analysed by nonlinear static analysis in ANSYS software. The response of the isolator under compressive load and displacement controlled condition by varying coefficient friction values are analysed. The analysis is done with five coefficient of friction values (0.02, 0.04, 0.06, 0.08 and 0.1) and then it represented graphically. From the results, as coefficient of friction increases the stress intensity and the von Mises stress of the model increases.

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