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Influence Analysis of Tuned Mass Damper on the Existing Piping Stress Analysis

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1. Introduction

Recently, there has been a strong earthquake around nuclear power plants. Accordingly, an increase in seismic performance is required for existing facilities. If this method of improving seismic performance greatly affects the existing design, it will be impossible or will cause time and cost problems. Research on Tuned Mass Damper (TMD) is being conducted to improve the seismic performance of the nuclear piping system [1, 2]. The advantage of the TMD is that it can increase seismic performance with little impact on existing designs. Accordingly, the piping stress analysis before and after installation of the TMD is compared, and the influence on the existing piping design is analyzed.

2. Methods and Results

2.1 Tuned Mass Damper

Figure 1 shows the actual TMD configuration developed to improve the seismic performance of the nuclear piping system. The TMD is clamped to the straight pipeline, and the total weight is 5.8% of the first modal mass of the piping system. The TMD is designed by the piping system dynamic mode and increases seismic performance by dissipating energy instead of piping.

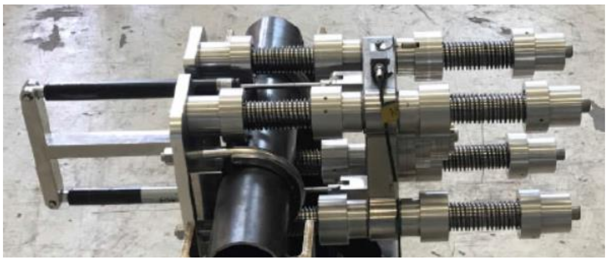

Fig. 1. Actual configuration of the TMD

2.2 Target Piping System

The target piping system is part of the Chemical and Volume Control System (CVCS) actually applied to OPR1000 (Optimized Power Reactor) and APR1400 (Advanced Power Reactor). The piping subsystem includes a charging inlet line and is conservatively anchored in a specific piping area. Table I shows the pipe data of the subsystem.

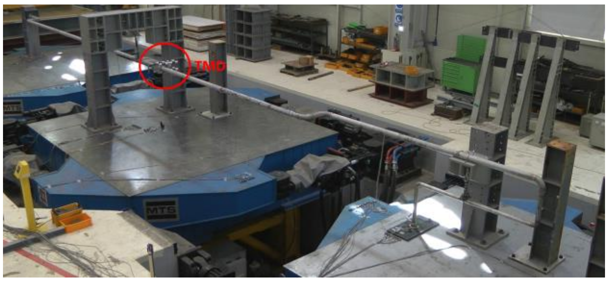

Fig. 2. Configuration of piping system for shaking table test

Table I: Pipe Data of the Subsystem

NPS, inch	Sch. 160S, mm	D_o, mm	Material	
			Spec.	Gr.
2	8.74	60.3	ASME SA312	TP316
3	11.13	88.9		

NPS: Nominal Pipe Size
Sch.: Schedule
D_o = outside diameter of pipe, mm

2.3 Influence Analysis of TMD

Based on the shaking table test results, a piping numerical model using finite element is developed and validated. For analysis of the influence of the TMD, the ANSYS was used as a numerical analysis program. Figure 3 shows finite element model of the piping subsystem. Table II shows the comparison results of stress analysis with and without the TMD.

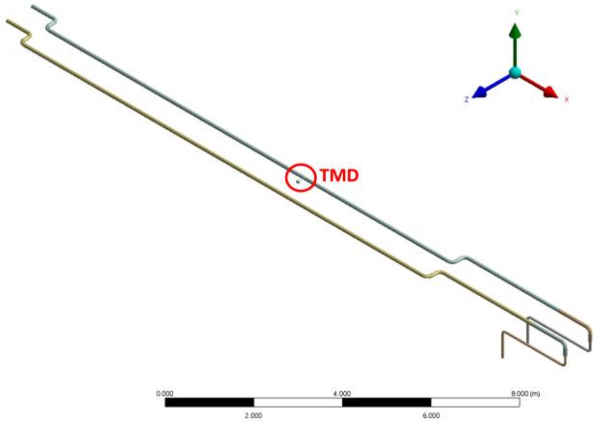

Fig. 3. Finite element model of the piping subsystem

Table II: Comparison Results of Piping Stress Analysis

Type	1st Mode, Hz	Max. Disp., mm	Max. Stress, MPa
w/o TMD	2.0	6.6	88.9
w/ TMD	1.7	4.7	56.9
Ratio, %	-	71	64

Since the purpose of this study is to compare the presence or absence of the TMD and analyze the impact on the existing design, the maximum displacement and stress applied with the Design Ground Response Spectrum (DGRS) of USNRC Regulatory Guide 1.60 [3] are calculated. As shown in Table II, when the TMD is installed, both the maximum displacement and stress for earthquakes become smaller, so the TMD has little effect on the existing design or acts more positively on the stress limit.

3. Conclusions

In this study, the influence analysis of the TMD on the existing piping stress analysis is performed. From the numerical analysis verified by the shaking table tests, it can be seen that the TMD has little effect on the existing piping design or acts more positively on the stress limit. Therefore, it is possible to increase seismic performance by attaching the TMD without much impact on the existing design, such as adding snubbers or supports. This study can be expanded to other types of seismic excitation and check acceleration, stress intensity, force, and moment.

ACKNOWLEDGEMENTS

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