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EFFECT OF MULTI-SUPPORT EXCITATION ON SEISMIC BEHAVIOR OF TFPS-ISOLATED CABLE STAYED BRIDGE

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Abstract - *The seismic response of cable stayed bridge isolated with Triple Friction Pendulum System (TFPS) is investigated under multi-support excitation using SAP2000. Dynamic response of bridge is executed by the non-linear time history method. Predominantly, isolation mechanisms are placed under the deck & abutment of cable stayed bridge but in this study isolation mechanism are placed under pylon & abutment. Analysis result shows that base shear and acceleration are decreased whereas displacement is increased in TFPS-isolated bridge with multi-support excitation as compared to TFPS-isolated bridge without multi-support excitation.*

Keywords- *Cable Stayed bridge, Base Isolation, Triple Friction Pendulum System., Multi-support Excitation, SAP2000*

I. INTRODUCTION

Cable stayed bridge is one of the most captivating structure. There are various types of cable arrangement like fan, harp and semi fan type. From the study of damages caused by past earthquakes, it has been found that the response of bridges is generally governed by the response of bearings and substructure. Efficiency of isolation bearings, especially in case of cable stayed bridges and selection of a proper isolation bearing is also an important task. From the literature view, it is finalized that there is insufficient work found individually in the seismic analysis of cable stayed Bridge with Triple Friction Pendulum System (TFPS) using multi-support excitation. The objectives of studies are,

- To study the multi-support excitation effect on TFPS isolated cable stayed bridge under the near-fault ground motions.
- To evaluate the response of TFPS isolated cable stayed bridge isolated with and without multi-support excitation.

II. LITERATURE SURVEY

Li and Yang (2008) investigated effects of multi-support excitation on seismic response of a long span prestressed concrete continuous rigid frame bridge. They considered local effect, passage effect as well as incoherence effect and in numerical simulation. They concluded that uniform seismic excitation is not able to control the seismic design for long span rigid framed bridge and influence of multi-support excitation must be considered for the rigid framed bridge. Atmaca and Ates (2012) evaluated three dimensional finite element model of base isolated and non isolated bridge modeled using SAP2000 to know dynamic response of bridge. Atmaca et al. (2014) carried out non-linear dynamic analysis of base isolated cable stayed bridge under earthquake motions. They concluded that the isolation devices placed under pylon and abutment as compared to isolation device placed under the deck of bridge are more effective when the bridges are under earthquake ground motions. Dhankot and Soni (2016) investigated response of building isolated with triple friction pendulum bearing. They concluded that TFPS is found efficient in reducing bearing displacement; base shear as well as acceleration stacks up against to friction pendulum system (FPS). Parekh et al. (2016) investigated the seismic response of cable stayed bridge isolated with FPS and TFPS. They concluded that TFPS is more effective than that of other isolation system.

III. MULTI-SUPPORT EXCITATION (MSE)

The presence of spatial variation in ground motion leads to the different excitation at different support point of a structure such as pier and pylon of the bridge which is known as multi-support excitation (MSE). For multi-support excitation acceleration time history converted into displacement time history. After that displacement ground motion record applied to the support. After defining joint pattern, unit displacement value applies in longitudinal direction. Define a time-history load case which specifies the displacement.

IV. PROBLEM FORMULATION

In this study, the cable bridge is selected for numerical study. This cable bridge is as same as the bridge constructed in Turkey, Atmaca and Ates (2012). The bridge is divided into two equal spans. Cross section area of the bridge tower is hollow hexagonal. Composite section is used for deck of bridge which consists of 25 cm thick concrete, 10 cm thick asphalt. 28 no. of cables are used to support the deck which are tie-up to tower. I cross section steel girder is used in deck from one end to another end of the bridge. Distance between the pylon and nearest cable is 19.6 m and distance between abutment and nearest cable is 9.4 m. Distance between intermediate cable is 12 m. Pylon is rested on the 1 m thick concrete base. The description of the bridge is given below.

Bridge: Manavgat cable stayed bridge
Location: Turkey
Span length: 202 m
Pylon height: 42 m
Pylon shape: Inverted Y-shape
C/s of pylon: 2.128 × 2.850 m^2
Mass density: 24 kN/m^3
Elastic modulus (strand): 1.97×10^5 kN/m^2

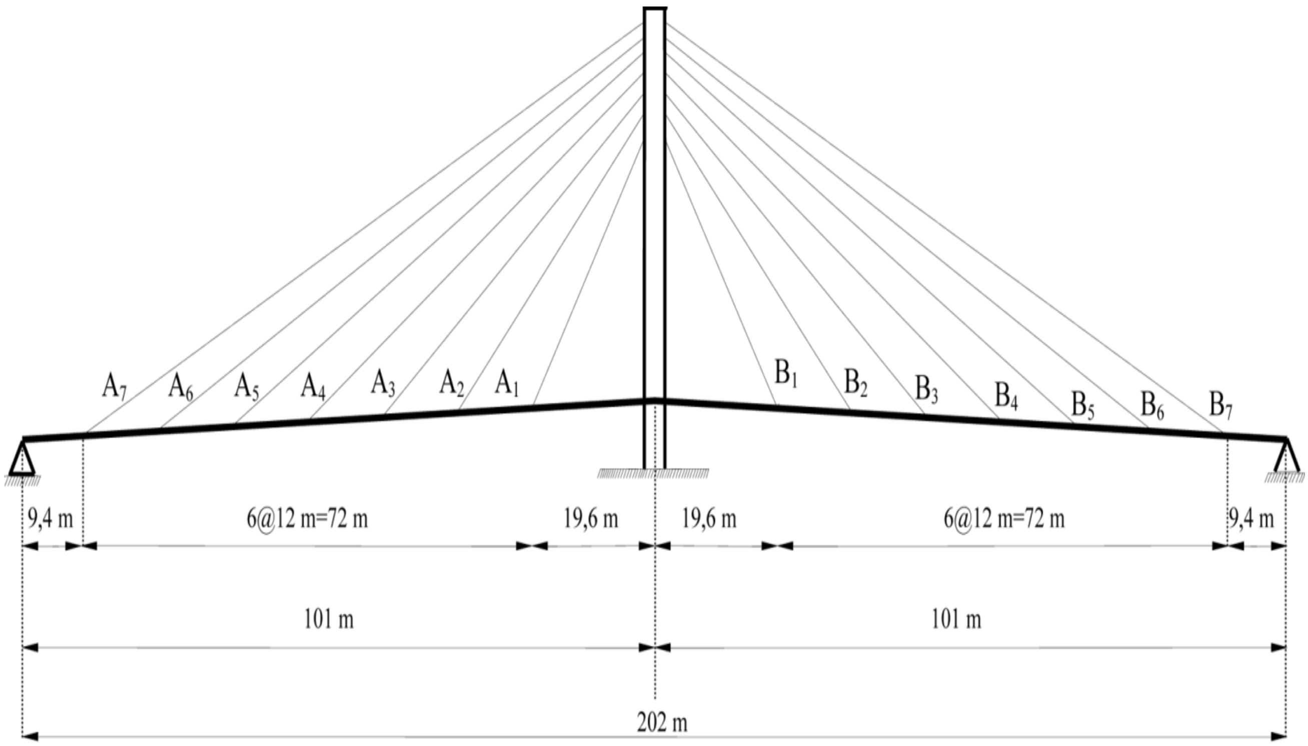


Figure 1 Schematic diagram of Manavgat Cable Stayed Bridge

Table 1 Cable Data

Cable No (A = B)	Diameter(m)
A_1	0.228
A_2	0.243
A_3	0.288
A_4	0.288
A_5	0.344
A_6	0.288
A_7	0.364

Table 2 Lateral Directional Properties of TFPS

Parameter	Outer Top	Outer Bottom	Inner Top	Inner Bottom
Effective Stiffness (kN/m)	4274.69	4274.69	4247.69	4274.69
Elastic Stiffness (kN/m)	703045.7	703045.7	703045.7	703045.7
Friction Coefficient Slow	0.08	0.08	0.02	0.02
Friction Coefficient Fast	0.08	0.08	0.02	0.02
Rate Parameter	1	1	1	1
Net Pendulum Radius (m)	0.81	0.81	0.18	0.18
Stop Distance (m)	0.571	0.571	0.225	0.225

V. NEAR-FAULT GROUND MOTIONS

To evaluate the seismic response of cable stayed bridge, three near-fault ground motions such as Imperial Valley (El Centro Array#5, 1979), Imperial Valley (El Centro Array#6, 1979), Northridge, (Newhall 1994), are used for analysis of cable stayed bridge. The N-S component of earthquake is applied in longitudinal direction of the bridge. Table 3 shows the Peak ground acceleration (PGA), Peak ground velocity (PGV) and Peak ground displacement (PGD) of near-fault ground motions.

Table 3 Ground Motion Data

Earthquake	Recording station	PGA (g)	PGV (m/sec)	PGD (m)
Imperial Valley,1979	El Centro Array #5	0.37	0.98	0.765
Imperial Valley, 1979	El Centro Array #6	0.46	1.13	0.491
Northridge, 1994	Newhall	0.72	1.19	0.381

VI. ANALYSIS REASULTS AND DISCUSSION

A) Time period

Figure 2 shows comparison of time period for non isolated and TFPS-isolated bridge. From the figure, it is observed that time period is more in case of TFPS-isolated bridge in comparison to non-isolated bridge.

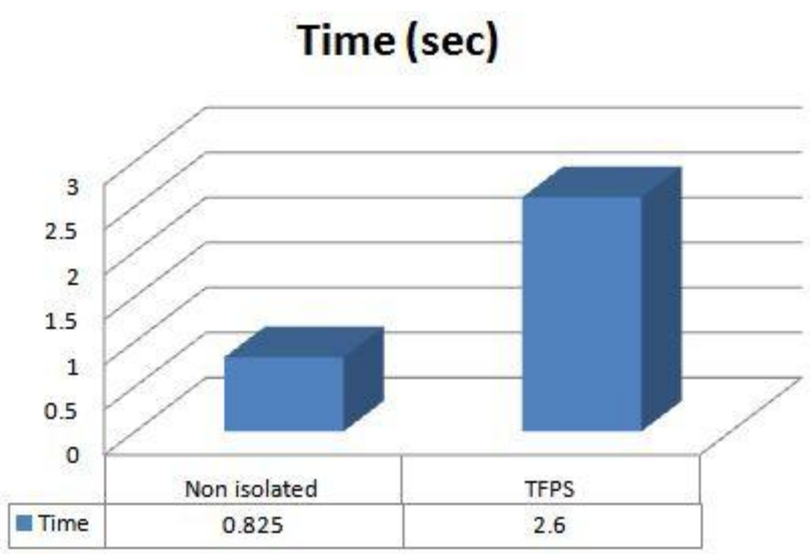


Figure 2 Comparison of time period of non-isolated and isolated bridge

B) Base Shear

Figures 3 and 4 show comparison of base shear of TFPS-isolated bridge without multi-support excitation and with multi-support excitation. Base shear is less than that of TFPS-isolated bridge with multi-support excitation in comparison to without multi-support excitation.

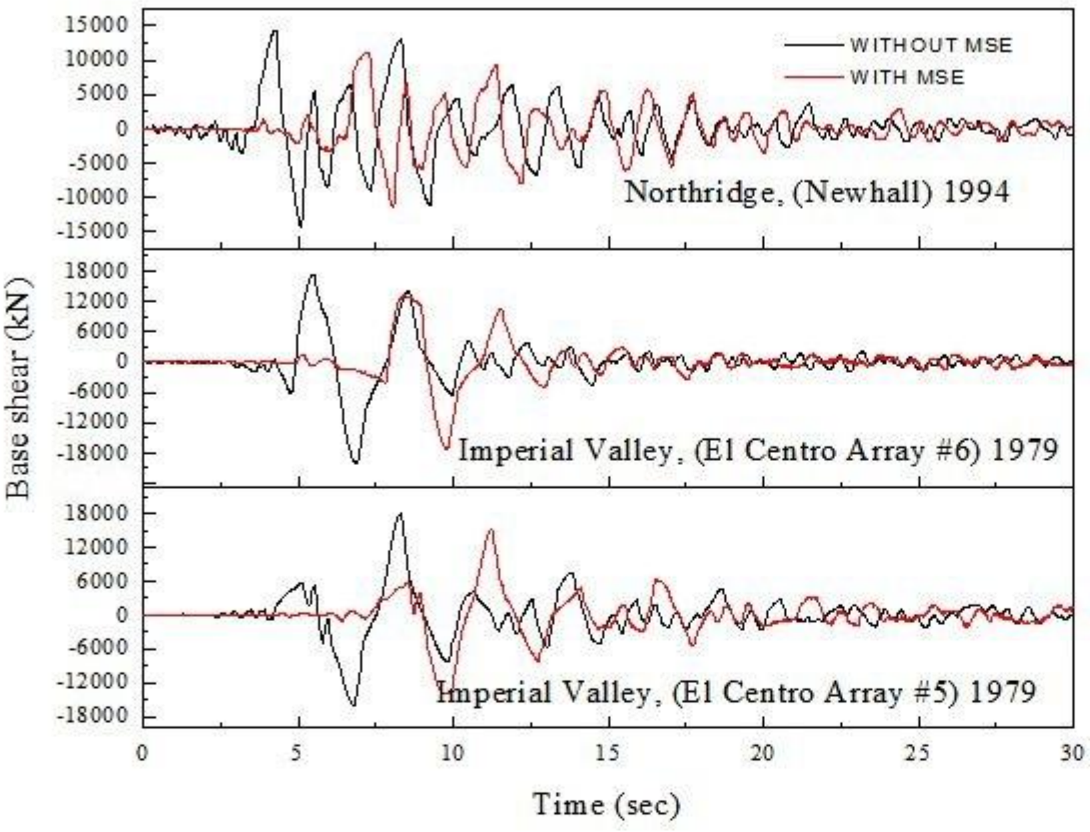


Figure 3 Comparison of base shear for with and without MSE

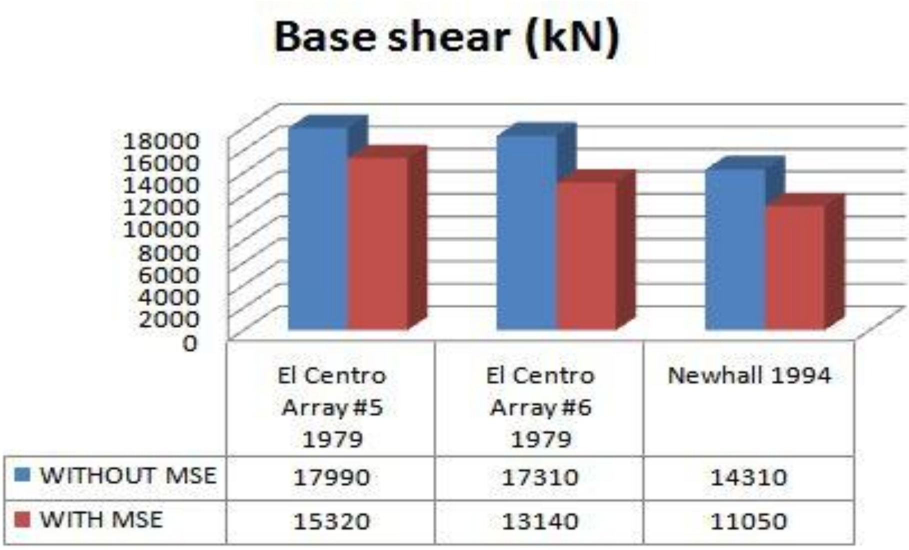


Figure 4 Comparison of base shear for with and without MSE

C) Deck acceleration

Figures 5 and 6 show comparison of deck acceleration of TFPS-isolated bridge without multi-support excitation and with multi-support excitation. Deck acceleration is less than that of TFPS-isolated bridge with multi-support excitation in comparison to without multi-support excitation.

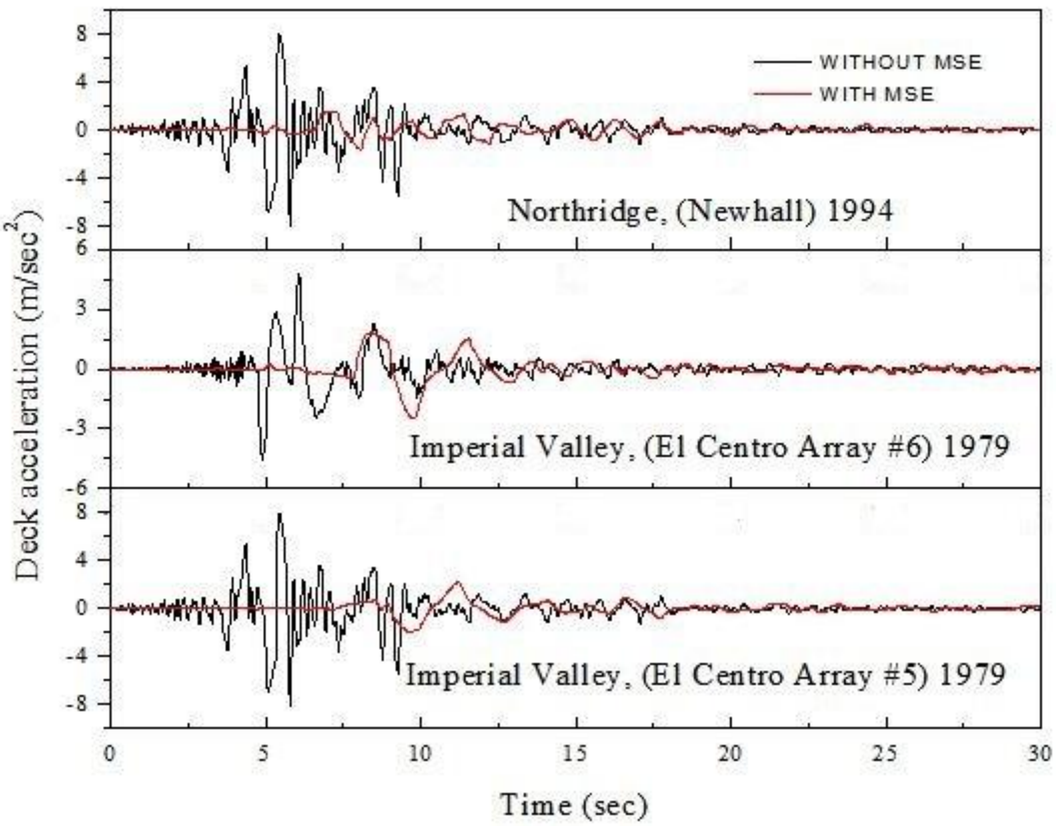
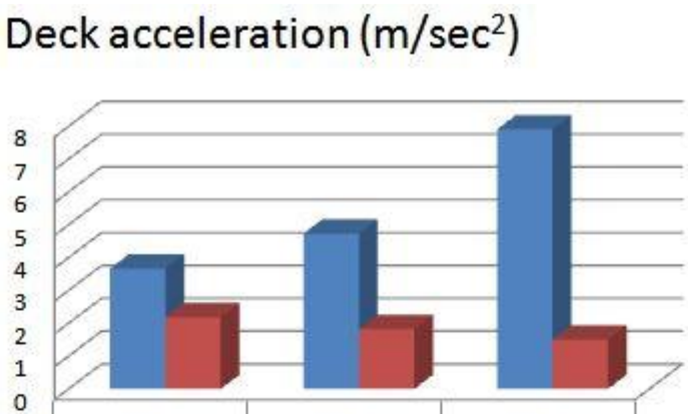


Figure 5 Comparison of deck acceleration for with and without MSE



	El Centro Array #5 1979	El Centro Array #6 1979	Newhall 1994
WITHOUT MSE	3.667	4.736	7.912
WITH MSE	2.186	1.819	1.505

Figure 6 Comparison of deck acceleration for with and without MSE

D) Bearing displacement (m)

Figures 7 and 8 show comparison of bearing displacement of TFPS-isolated bridge without multi-support excitation and with multi-support excitation. Bearing displacement is more than that of TFPS-isolated bridge with multi-support excitation in comparison to without multi-support excitation.

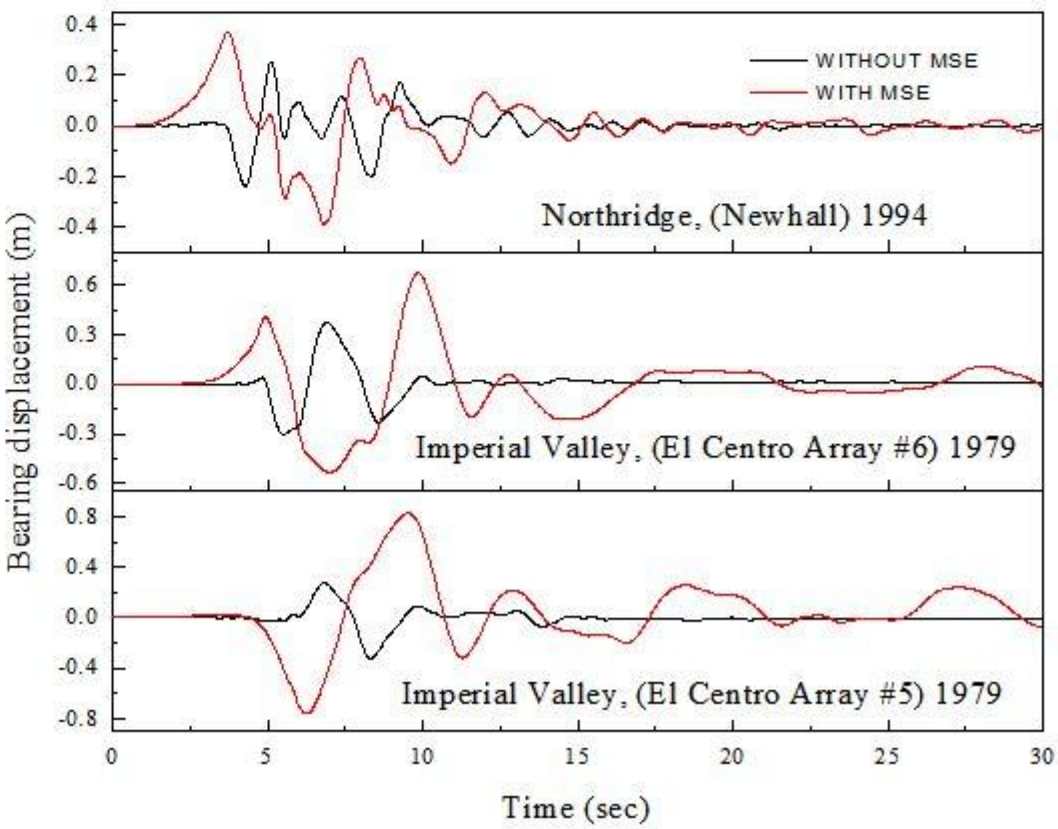


Figure 7 Comparison of bearing displacement for with and without MSE

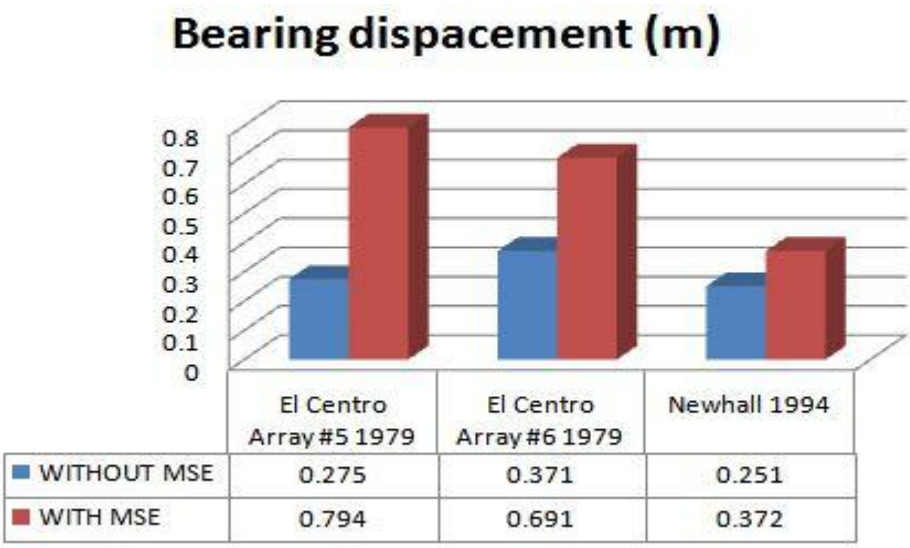


Figure 8 Comparison of bearing displacement for with and without MSE

E) Hysteresis behavior

Figure 9 shows the hysteresis behavior of cable stayed bridge under near-fault ground motions. It is observed that hysteresis behavior of the bridge depends on the ground motions characteristics. For the El Centro Array #5 (1979), El Centro Array #6 (1979) and Newhall (1994) TFPS isolator reach to the regime IV.

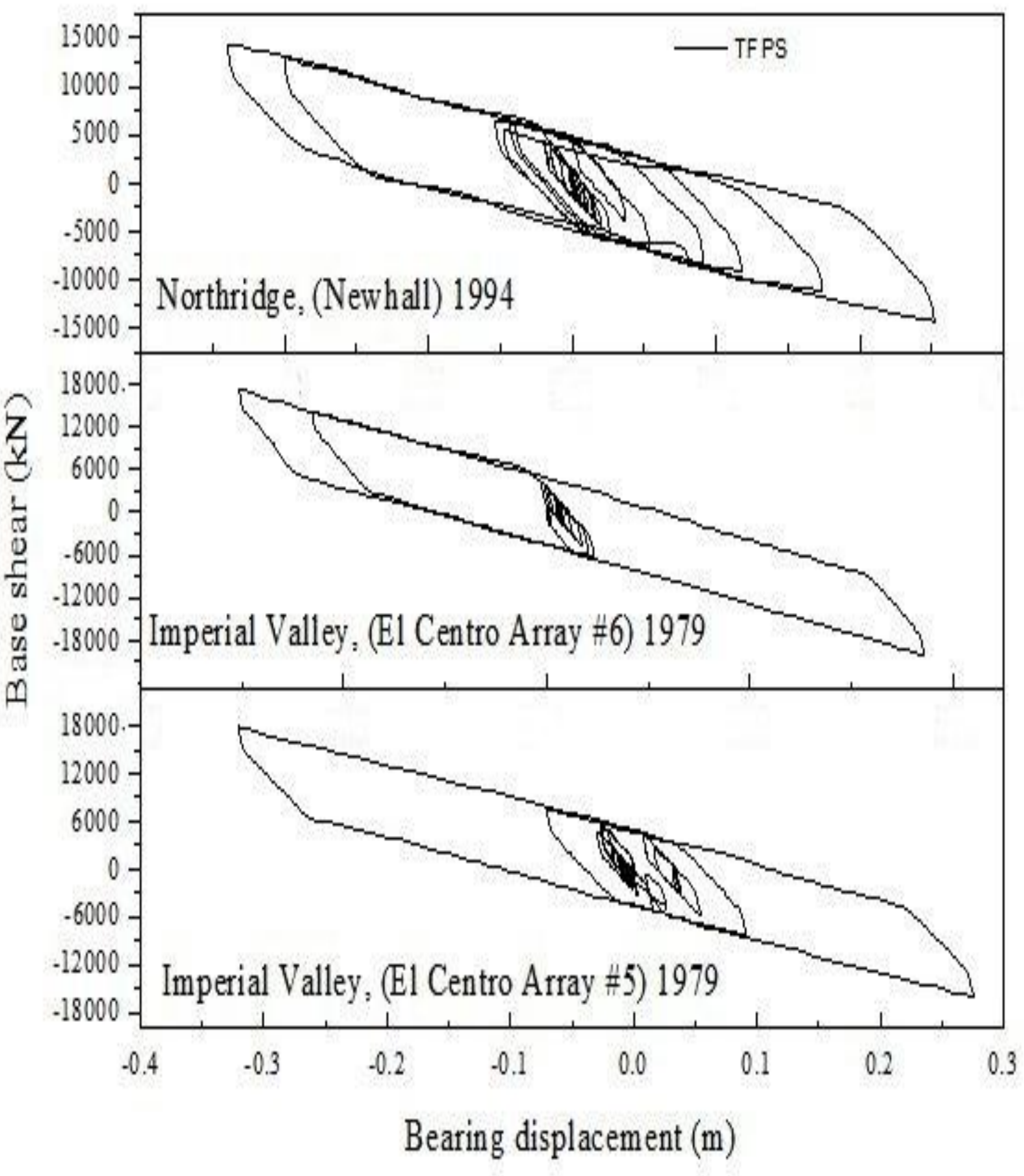


Figure 9 Hysteresis behavior for TFPS

VII. CONCLUSIONS

In this study seismic response of TFPS-isolated cable stayed bridge using multi-support excitation has been investigated using SAP2000. On the basis of results conclusion are made as:

1. Base shear for multi-support excitation is reduced by 20.5% as compared to without multi-support excitation.
2. It is observed that deck acceleration for multi-support excitation is reduced by 60% than that of without multi-support excitation.
3. It is also concluded that displacement capacity of bearing is increased for multi-support excitation compared without multi-support excitation.
4. Multi-support excitation plays huge role for long span bridge.

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