SEISMIC RESPONSE OF SUSPENSION TRANSMISSION LINE TOWER UNDER FORWARD DIRECTIVITY AND FLING STEP GROUND MOTIONS

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Abstract : The aim of this paper is to study the seismic response of suspension transmission line tower under different ground motions. The effects of far-field ground motions, near-fault ground motions with forward directivity ground motions and fling-step ground motions are assessed on the response of transmission line tower. Four legged tower is analyzed using ETABS software. Results show that the response of suspension transmission line tower is less sensitive to far-field ground motions compared to near-fault ground motions for the reason that of inherent large velocity pulse and permanent ground deformation. The responses are higher in case of near-fault ground motions with forward directivity than in case of fling-step effect.
Keywords: Transmission line tower, Fling step, Forward directivity, Ground motions.

I. INTRODUCTION

In India, the demand of electricity usage had been often growing so that it is important to transfer electricity to every part of the society. While planning and designing for a transmission line, a number of conditions should be kept in mind such as electrical and structural point of view. However, the certain regions are liable to to moderate to severe earthquakes, Seismic loads might be vital for the reason that the transmission line towers and the cables might be subjected to higher force and stressed during ground motion. Therefore, earthquake forces may be important in designing of transmission line tower in high earthquake zones of the country.

In recent research, Yoganantham and Helen [1] carried out dynamic analysis of transmission tower under earthquakes. They analysed triangular and square tower and concluded that triangular tower behaves well as compared to square tower under earthquake ground motions. Srikanth and Satyam [2] carried out dynamic analysis of transmission line tower. They concluded that the axial force in leg member is increased under the earthquake load. Kalkan and Kunnath [3] carried out effect of fling-step as well as forward directivity on seismic behaviour on buildings. They concluded that fling-step effect is more damaging compared to far-field ground motions. Dhankot and Soni [4] studied on bridge isolated with TFPS under the far-field, forward directivity as well as fling-step ground motions. They have analysed the response are much higher in case of forward directivity than in case of fling step effect. From the literature study, it is found that no attempt has been made on study of transmission line tower under forward directivity as well as fling-step ground motions. To address above concern, dynamic analysis of tower is carried out by using ETABS software. Specific objective of the study is to obtain the response of transmission line tower under the far-field, forward directivity as well as fling step effect.

Directivity is a phenomenon in which velocity of fault separation is very close to velocity of shear wave. This leads to long period velocity pulses which appear to be stronger when rupture propagates towards the site (forward directivity). Forward directivity generates large-amplitude, long period and short duration. Fling-step is a strong velocity pulse which originates from the permanent tectonic ground movement connected with the separation mechanism. Fling-step generates short amplitude, short period and long duration.

II. DETAILS OF GROUND MOTIONS

Table 1: Details of far-field, forward directivity and fling-step ground motions

Sr No.	Name and Designation of earthquakes	Magnitude (Mw)	Station	PGA (g)	Fling Displacement (m)
Far-field ground motions					
1	Loma prieta, 1989	6.9	Capitola	0.420	-
2	Chamoli, 1999	6.4	Chamoli	0.359	-
3	Superstition Hill, 1987	6.7	El Centro Imp. Co.	0.512	-
4	Imperial Valley, 1940	6.95	El Centro	0.313	-
5	Northridge, 1994	6.7	Canoga Park - Topanga Canyon	0.477	-
6	Northridge, 1994	6.7	Northridge-Saticoy	0.529	-
Near-fault ground motions with forward directivity					
1	Imperial Valley, 1979	6.4	El Centro Array #5	0.370	-
2	Imperial Valley, 1979	6.4	El Centro Array #7	0.460	-
3	Northridge, 1994	6.7	Newhall	0.720	-
4	Landers, 1992	7.3	Lucerne Valley	0.710	-
5	Northridge, 1994	6.7	Rinaldi	0.890	-
6	Northridge, 1994	6.7	Sylmar	0.730	-
Near-fault ground motions with fling-step					
1	Chi-Chi, 1999	7.6	TCU052_NS	0.440	6.97
2	Chi-Chi, 1999	7.6	TCU074_EW	0.590	1.74
3	Chi-Chi, 1999	7.6	TCU084_NS	0.420	0.594
4	Chi-Chi, 1999	7.6	TCU129_NS	0.610	0.675
5	Chi-Chi, 1999	7.6	TCU068_EW	0.500	6.01
6	Kocaeli, 1999	7.4	YPT_NS	0.230	1.45

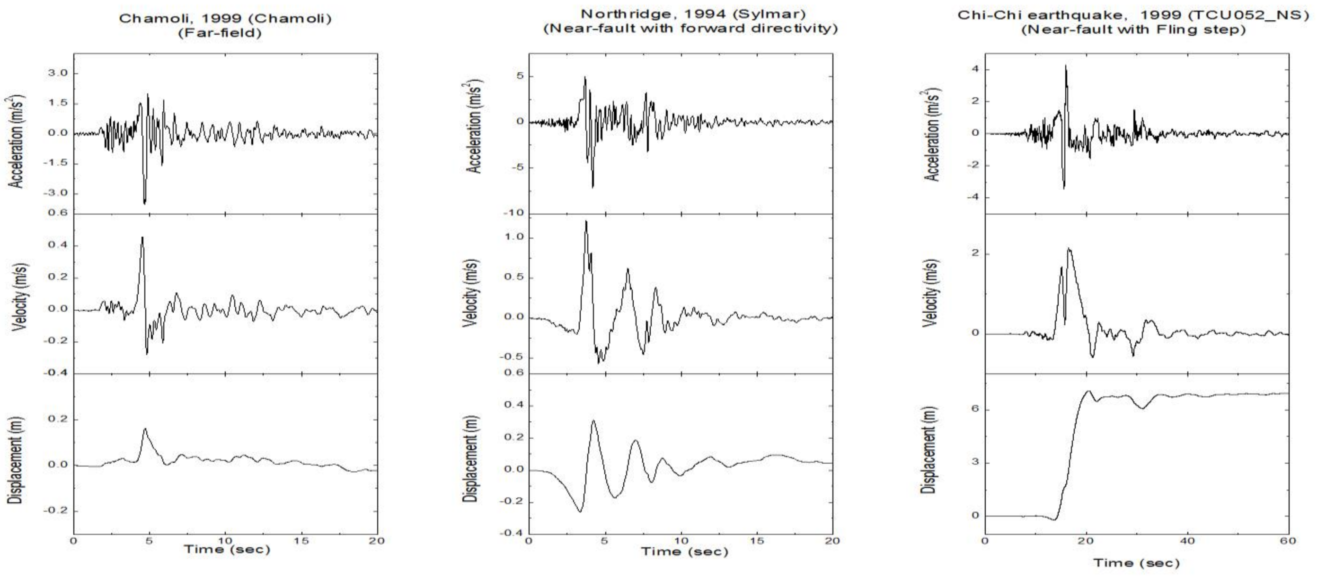

Figure 1: Typical Acceleration, Velocity as well as Displacement time histories of (a) far-field ground motions, (b) forward directivity, (c) fling-step ground motions

The Acceleration, Velocity as well as Displacement histories of typical far-field ground motions (Chamoli 1999, Chamoli) are compared with that of forward directivity (Northridge 1994, Sylmar) and fling-step ground motions (Chi-Chi earthquake 1999, TCU052) as shown in Figure 1.

III. NUMERICAL STUDY

In this study, four legged suspension transmission line tower is used and analysis of transmission line tower is carried out using ETABS software. Height of tower is 38m [5]. Tower is analysed under different types far-field, forward directivity and fling-step ground motions. Response quantities considered are displacement of top node, base shear and axial force of member. Figure 2 shows four legged suspension transmission line tower and maximum displacement occurs at top node and axial force occurs at member (B17). Results obtained from analysis are shown in Figures 3-5.

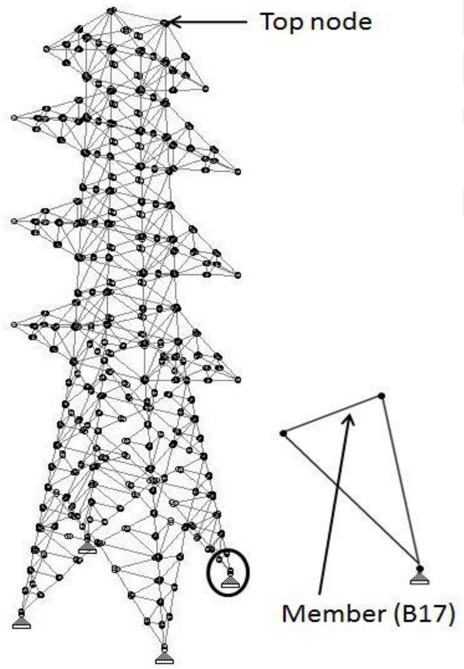

Figure 2: Four legged suspension transmission line tower

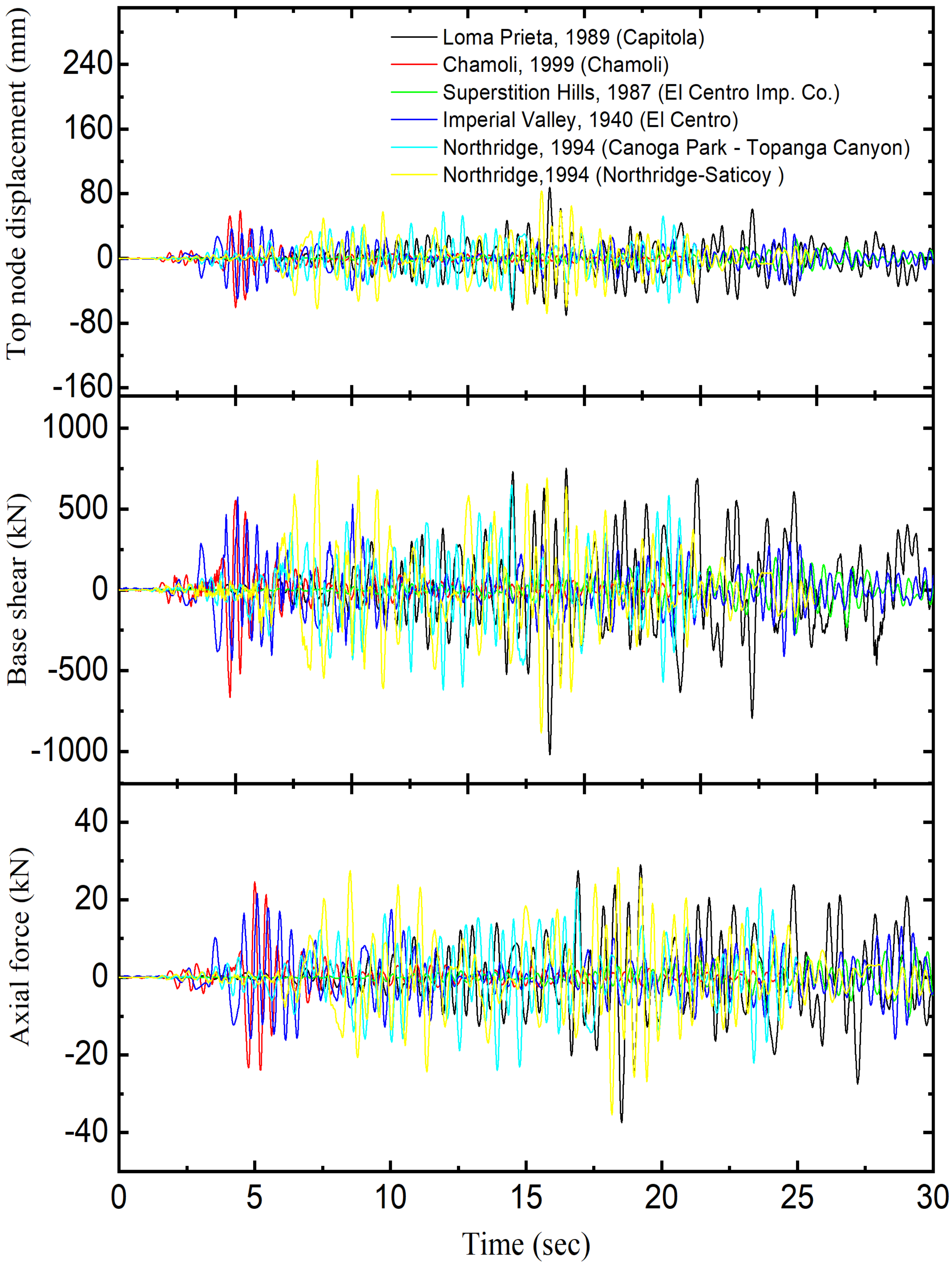

Figure 3: Time variation of top node displacement, base shear and axial force in member (B17) of suspension transmission line tower under far-field ground motions

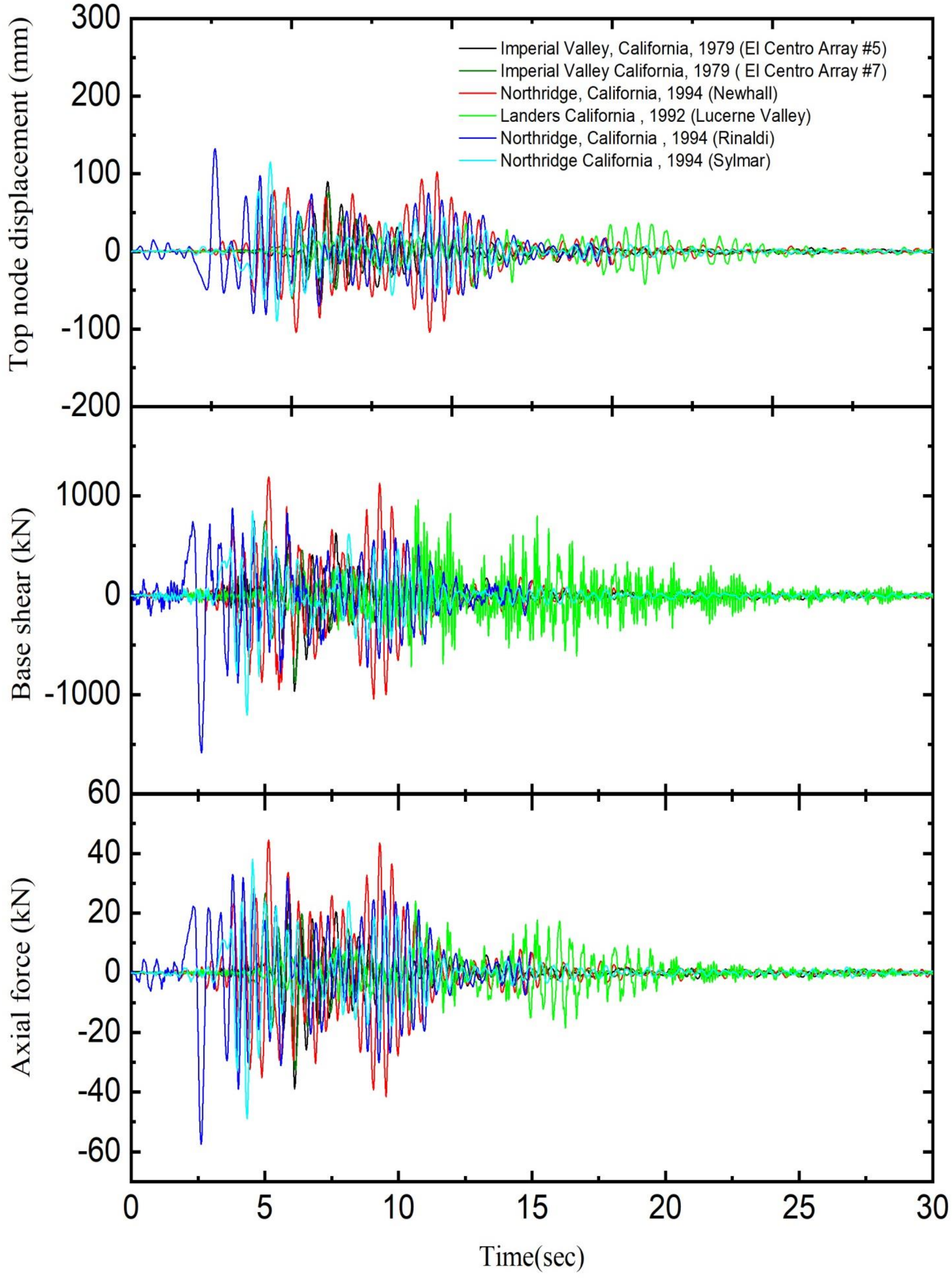

Figure 4: Time variation of top node displacement, base shear and axial force in member (B17) of suspension transmission line tower under forward directivity effect

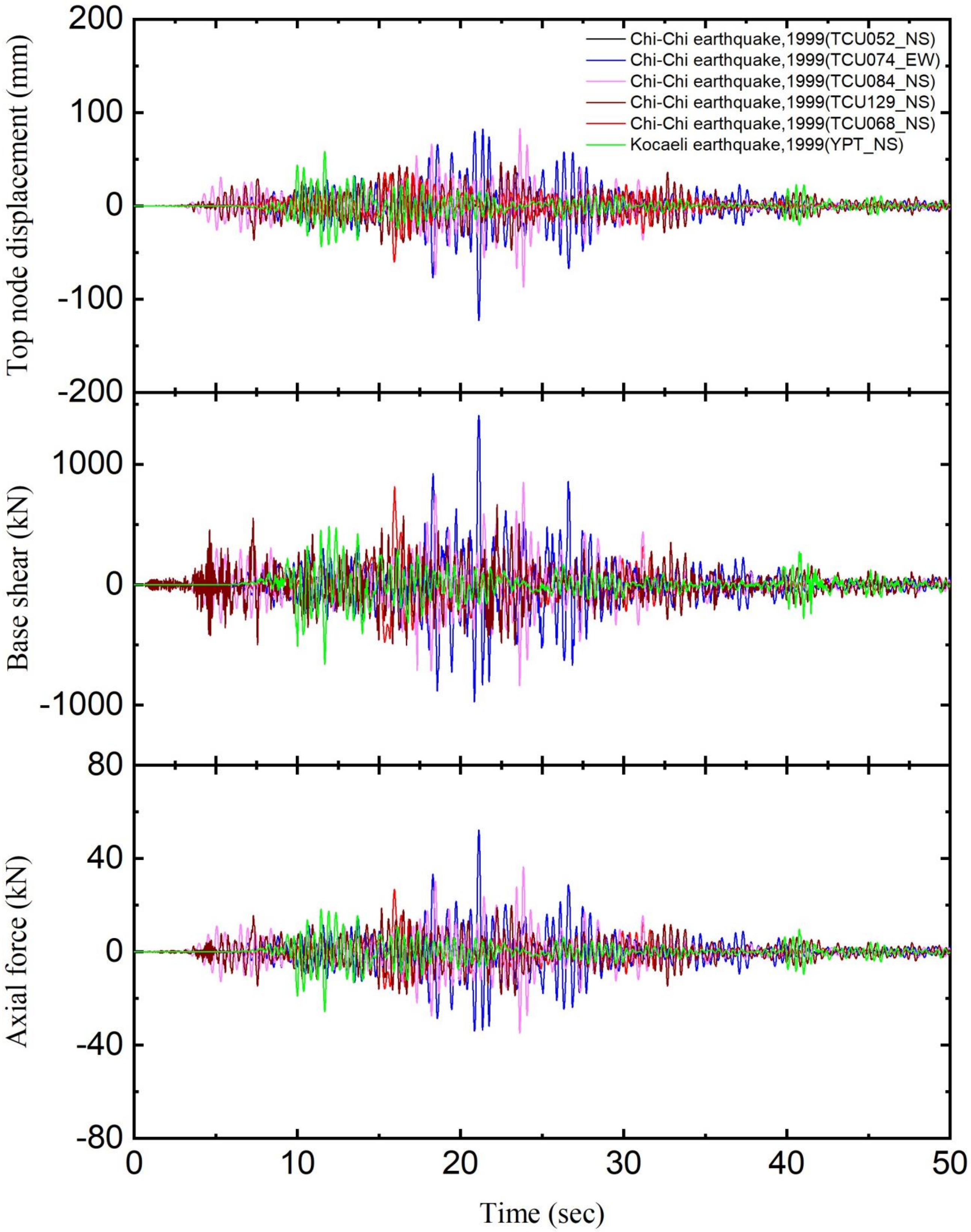

Figure 5: Time variation of top node displacement, base shear and axial force in member (B17) of suspension transmission line tower under fling-step effect

Table 2: Peak response quantity of transmission line tower under far-field ground motions

Far-Field Ground Motion	Top Node Displace-ment (mm)	Base Shear (kN)	Axial Force (kN)	
			Tension	Compression
Loma Prieta, 1989 (Capitola)	87.99	753.74	29.04	37.04
Chamoli, 1999 (Chamoli)	58.99	552.22	24.57	23.84
Superstition Hills, 1987 (El Centro Imp. Co.)	23.88	201.84	7.82	10.22
Imperial Valley, 1940 (El Centro)	39.93	576.17	21.56	16.23
Northridge, 1994 (Canoga Park - Topanga Canyon)	57.69	646.8	23.04	24.07
Northridge,1994 (Northridge-Saticoy)	83.14	799.49	28.28	35.39
Average Response	58.60	588.37	22.38	24.46

Table 3: Peak response quantity of transmission line tower under forward directivity

Near-Fault Ground Motion With Forward Directivity	Top Node Displace-ment (mm)	Base Shear (kN)	Axial Force (kN)	
			Tension	Compression
Imperial Valley, California, 1979 (El Centro Array #5)	90.25	628.04	28.03	38.91
Imperial Valley California, 1979 (El Centro Array #7)	76.47	748.71	26.7	32.76
Northridge, California , 1994 (Newhall)	102.74	1193.4	44.52	41.57
Landers California , 1992 (Lucerne Valley)	36.45	964.69	24.08	18.59
Northridge, California , 1994 (Rinaldi)	132.65	880.27	32.94	57.43
Northridge California , 1994 (Sylmar)	115.27	852.12	38.18	49
Average Response	92.30	877.88	32.40	39.71

Table 4: Peak response quantity of transmission line tower under fling-step ground motions

Near-Fault Ground Motion With Fling Step	Top Node Displace-ment (mm)	Base Shear (kN)	Axial Force (kN)	
			Tension	Compression
Chi-Chi Earthquake, 1999 (TCU052)	36.26	813.83	26.82	15.82
Chi-Chi Earthquake, 1999 (TCU074)	82.16	1405.0	52.20	33.98
Chi-Chi Earthquake, 1999 (TCU084)	82.72	850.81	36.41	34.91
Chi-Chi Earthquake, 1999 (TCU129)	46.82	665.74	19.87	18.84
Chi-Chi Earthquake, 1999 (TCU068)	46.50	912.13	27.82	17.81
Kocaeli Earthquake, 1999 (YPT)	58.5	485.8	18.33	25.72
Average Response	58.82	855.55	30.24	24.51

Table 5: Average response of transmission line tower under far-field, forward directivity and fling-step ground motions

Average Response	Displacement (mm)	Base Shear (kN)	Axial Force (kN)	
			Tension	Compression
Far fault ground motions	58.60	588.37	22.38	24.46
Forward directivity ground motions	92.30	877.88	32.40	39.71
Fling step ground motions	58.82	855.55	30.24	24.51

Figures 3-5 show the time vs response quantity of tower under far-field, forward directivity as well as fling-step ground motions. Tables 2-4 show the peak response quantity under far- field, forward directivity as well as fling-step ground motions. Table 5 shows the average response of far-field, forward directivity as well as fling step ground motions. It can be seen that average response of tower under forward directivity ground motion is more as related to far-field and fling-step ground motions.

IV. CONCLUSIONS

The response of a four legged suspension transmission line tower is studied under far-field, forward directivity as well as fling-step ground motions. From this study, conclusions are as follow:

1. The response of suspension transmission line tower is less sensitive to far-field ground motion compared to near-fault ground motions for the reason that inherent large velocity pulse and permanent ground deformation.

2. The response of suspension transmission line tower is higher in case of forward directivity than in case of fling-step effect.

V. REFERENCES

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