5. LOAD ANALYSIS

5.1. ANALYSIS MODEL

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5.3. GROUND SPRINGS AT PILE FRAMES

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5.1 ANALYSIS MODEL

Notes on Analysis Model

Structural analysis, including multimode analysis for seismic response, is obtained from a SAP 2000 stick model.

The stick model is a full 3D model of the flyover structure; vertical and horizontal alignment is assured from importing the final 3D CAD model of the structure. The deck elements are located at the centroid of the permanent load (including superimposed load) – refer to Section 5.2 for a summary of deck centroid elevations.

The loads presented in Section 4 were applied to the model. Live loads were applied to maximize the response in the substructure. Moving loads were applied in corresponding lanes to model truck and KEL loading. Uniformly distributed loads were applied both span by span and on two adjacent spans at a time to model the lane loading.

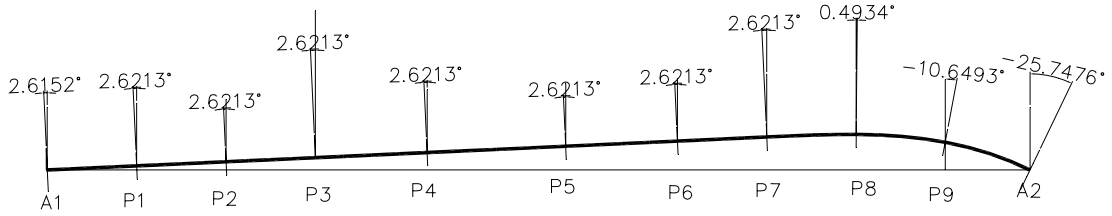
The model takes account of soil structure support with non linear ground springs. Non-linear analysis was used to establish structure stiffness under earthquake load in each direction. Multimode analysis in each direction is based on this non-linear soil-structure stiffness. Refer to Section 4 for the response spectrum used in the analysis.

The multimode analysis was undertaken for the first 30 modes (3 modes per span). Given the expansion joints at P3 and P6, two alternative models were analysed to determine the worst case:

1. "Expansion Case" : Frames analysed without longitudinal connection at P3 and P6 (frames restrained only for vertical and transverse displacements and deck torsion - frames free to rotate about y and z axes and translate along x axis)
2. "Compression Case" : Frames analysed assuming longitudinal pinned connection at P3 and P6 (frames restrained for vertical, longitudinal and transverse displacements and deck torsion – frames fee to rotate about y and z axes)

The results of the analysis are presented in Section 5.5.

Given the curved horizontal alignment of the structure three (3) coordinate systems were set up to analyse earthquake effects for both the expansion case and the compression case. The three (3) coordinate systems are as follows:



	X	Y	Z
A1	0.000	0.000	26.256
P1	19.979	0.915	27.121
P2	39.958	1.829	27.727
P3	59.937	2.744	28.187
P4	84.911	3.887	28.354
P5	115.879	5.305	28.218
P6	140.852	6.449	28.068
P7	160.831	7.363	27.71
P8	180.820	7.938	27.09
P9	200.718	6.202	26.207
A2	219.671	0.000	25.094

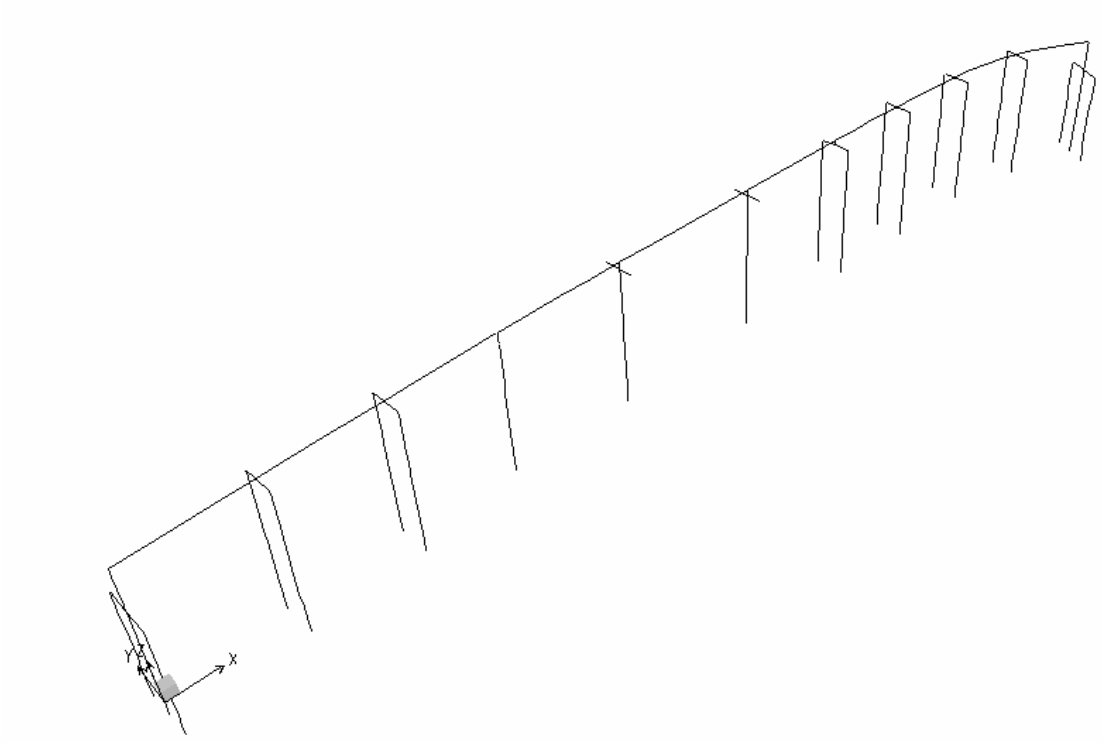
Refer to Section 5.3 for a presentation of the local axes at each substructure location.

Non linear soil springs for the pile determined based on JRA recommendations. Refer to Section 3.5 for detailed calculations of soil spring values and Section 5.3 for a summary of the equivalent ground springs used in the analysis model.

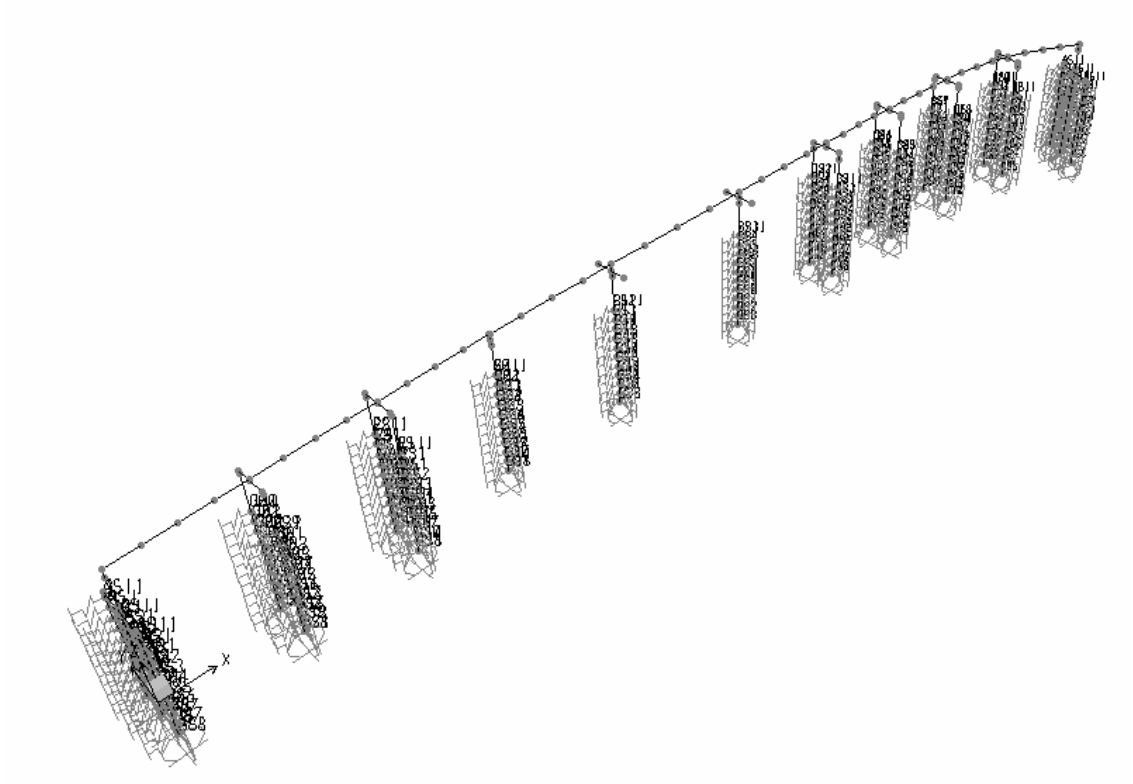
Refer to Section 5.4 for a summary of the analysis data of the structure model.

Separate pile element models are used to analyse the response of the piles to plastic hinging effects of the columns. The pile model also makes use of non linear ground springs to ensure that ultimate horizontal bearing capacity of the corresponding soil layers is not exceeded and to accurately determine the response of the piles (using cracked section properties). Refer to Section 10.3 for details of pier pile analysis.

Basic Frame Arrangement



Model Showing Ground Springs down Pile Frames



5.2 GROUND SPRINGS AT PILE FRAMES

Spring Ref	Depth (m)	LINEAR ANALYSIS Elastic Spring (kN/m)	NON LINEAR ANALYSIS Limiting Reaction (kN)	NON LINEAR ANALYSIS Yield Displacement (mm)
SS11	0.0	22000	350	18
SS1	2.0	45000	700	18
SS1	4.0	45000	700	18
SS2	6.0	85000	1350	18
SS3	8.0	85000	1500	18
SS4	10.0	250000	3100	15
SS5	12.0	250000	3200	15
SS6	14.0	160000	2700	15
SS7	16.0	330000	4150	15
SS7	18.0	330000	4150	15
SS8	20.0	330000	4400	15
SS8	22.0	330000	4400	15
SS9	24.0	330000	4700	15
SS9	26.0	330000	4700	15
SS10	28.0	330000	5000	15
SS10	30.0	330000	5000	15
SS10	32.0	330000	5000	15
SS10	34.0	330000	5000	15