Seismic Analysis for Achieving Economy and Safety in Bridge Structures

Etudes sismiques en vue de réaliser l'économie et la sécurité dans les structures de ponts

Erdbebenberechnungen für sichere und ökonomische Brücken

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1. INTRODUCTION

Static seismic coefficient method is generally used to carry out seismic analysis of bridge structures in India. Here seismic forces are evaluated from a coefficient specified by the code depending on the zone in which the bridge is located. Dynamic characteristics of the structure ignored resulting in very large forces and uneconomical design for bridges with tall piers. A case in point is the prestressed concrete railway bridge over River Sardan on Jammu Udhampur Rail Link, in India. General elevation and cross sectional details of the bridge are shown in the sketch below. A detailed dynamic analysis is required to be done for such structures to achieve economy in design and resultant saving in cost, without compromising on the safety of the structure.

2. DYNAMIC ANALYSIS

Dynamic analysis for this bridge involves determination of period and mode of oscillation for first five modes for the pier with superstructure mass lumped at the top and computation of horizontal shears and moments at various levels by mode participation method. Since the pier rests on bed rock, it is idealised as a cantilever fixed at base and divided into number of nodes along the height. The pier is described along Y-axis in the X-Y plane with oscillations being studied in X-direction. At the lowest node, all degrees of freedom are restricted. Other nodes are free to translate in X-direction and rotate about Z-axis, other degrees of freedom being restricted.

Mode shapes for first five modes of vibration with corresponding period of vibration are evaluated by using SAP 80 PROGRAM. Thereafter, mode participation factors are calculated for different modes. Average acceleration coefficient for each mode is calculated corresponding to appropriate period and damping (5% in this case) from Fig.2 of IS:1893 and also horizontal seismic coefficient is computed for each mode as under:

(As per Notations in IS: 1893) $\alpha h(r) = \frac{Sa}{g} (r) \; F \; I \beta$

Lateral load Q i (r) acting at any level i due to rth mode of vibration is given by the following equation:

$Q\,i\,(r) = Wi \; \phi \; i(r) \; Cr \, \alpha \, h\,(r)$

$Vi\,(r)$ Resultant shear at i level $= \sum_{i=1}^{i} Qi\,(r)$

3. RESULTS AND COMPARISON OF SEISMIC FORCES

Results of dynamic analysis for a typical pier of height 35.0 m are presented below in table 1 :

Table - 1

Mode No.	Period	Sa/g	h = Sa/g	Fp 1.P
1.	1.435	0.08	0.030	
2.	0.117	0.20	0.075	
3.	0.039	0.16	0.060	
4.	0.02	0.14	0.0525	
5.	0.012	0.13	0.049	

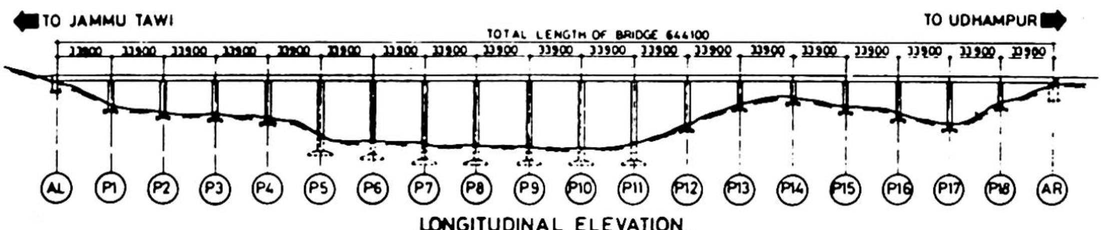
Resultant base moment by dynamic analysis = 10230 KN-M.
Resultant base moment by static coefficient (0.075g) = 25000 KN-M.

A comparison of seismic forces shows that the base moment obtained from dynamic analysis can be as low as 40% of the value computed by static seismic coefficient method. This results in economy in size of footing and a low reinforcement in the pier. Thus, a more realistic value of seismic analysis is obtained by dynamic analysis, especially for bridges with tall piers, resulting in reduction in cot of substructure.

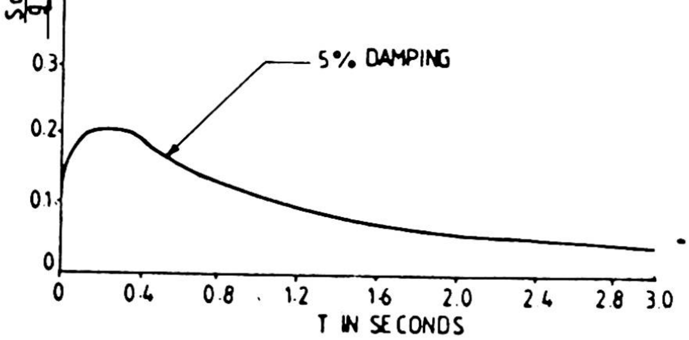
References:

1. IS: 1893 - Indian Standards Code of Practice for Earthquake Resistant Design of Structures.

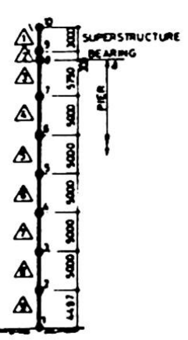
2. Earthquake Resistant Design of Bridges, University of Roorkee, India 425 - Refresher Course, 1984.



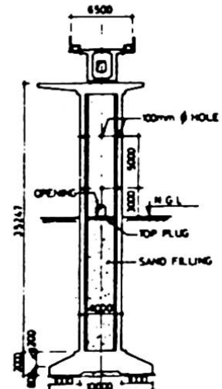
LONGITUDINAL ELEVATION



AVERAGE ACCELERATION SPECTRA



IDEALIZATION OF PIER



CROSS SECTION OF PIER