

INSTRUMENTAL MEASUREMENT OF NATURAL VIBRATION PERIODS
OF SOME HIGH-RISE REINFORCED CONCRETE BUILDINGS
IN ISTANBUL REGION

Alkut AYTUN

The Scientific and Technical Research Council of Turkey,
Building Research Institute - Ankara

ABSTRACT

First mode natural vibration pairs of 22 multistory buildings have been measured in İstanbul region, in respective principal axes.

The measurements were realized using a portable instrument developed by the author, with reasonably high reliability, and they characterize elastic oscillations of the structures with very small amplitudes.

The measured periods are compared with results, obtained by the empirical formulae $T = 0.09 H / \sqrt{D}$ and $T = 0.1 N$ (T = natural period in seconds, H = building height in meters, D =width of the building, in meters, measured in the considered direction, N =number of stories) as suggested by the current Earthquake Resistant Code of Turkey.

The extent and variety of differences of the estimated and measured periods are shown and it is concluded that a single formula can not be good enough for all types of buildings. Instead, the buildings should be collected in several groups and a different formula should be fitted to each. These groups are defined and modified coefficients are given as a first approximation.

INTRODUCTION

First mode natural vibration period pairs of 75 buildings have been measured in seismic regions of Turkey. Out of these, 22 samples were taken from İstanbul region, on the basis of availability of detailed design drawings.

The physical dimensions and periods are given in the following table. In cases where the floor plan is not a perfect rectangular, an equivalent rectangular is assumed with the same area, which coincides with the assumed principal axes.

Information about the instrument used, the measuring technics and the limitations are given elsewhere (2). At least six measurements were made for each case, and the successive values differed only in the third figure. Reliability of the measurements is sufficiently high.

In Figure 2, the measured periods are plotted versus H/\sqrt{D} and in Figure 3, versus N . The code formulae correspond to lines, passing through the origin and having slopes $\alpha = 0.09$ and 0.1 respectively. Both plots exhibit ample scattering.

As observed from the plots, the periods of the buildings on the high-rise end, are much lower than expected. They are structures, composed of rather thick, dense and crossing shear walls (e.g. bldg.

TABLE 1 - SAMPLED BUILDINGS

No.	Building	H (m)	D _x	H/√D _x	T _x	D _y	H/√D _y	T _y
1	İst. Sanayi Odası	70.00	15.70	17.67	1.12	35.60	11.73	0.72
2	İst. Etap Oteli	70.50	17.50	16.85	0.64	30.00	12.87	0.78
3	İst. Sheraton Oteli	82.50	15.00	21.30	0.74	25.00	16.50	0.65
4	Şişli 1. İmar İş Hanı	30.00	15.50	7.62	0.44	16.50	7.39	0.78
5	Harbiye Yeni Ordnevi	84.50	22.00	18.02	0.88	29.00	15.69	0.73
6	Hilton Oteli Eski Blok	50.00	23.51	10.31	0.82	35.20	8.77	0.68
7	Şişli Beytem İş Hanı	38.00	23.00	7.92	1.21	33.25	6.59	0.90
8	Şişli Günaydın İş Hanı	30.00	19.00	6.88	0.76	48.00	4.33	0.46
9	Şişli Abide Sitesi A-Blok	45.00	16.80	10.98	0.66	33.80	7.74	0.53
10	Şişli Abide Sitesi B-Blok	42.00	16.80	10.25	0.59	33.80	7.22	0.50
11	Şişli Abide Sitesi Yıldız Bl.	36.00	20.00	8.05	0.51	25.00	7.20	0.49
12	Ş. Abide Sitesi Arka B-Blok	28.00	22.00	5.97	0.45	33.75	4.82	0.41
13	Okmeyd. İETT Köp Büyük Blok	43.50	15.00	11.23	0.94	38.50	7.01	0.85
14	Okmeyd. İETT Yıldız Blok	49.00	21.00	10.69	0.96	25.00	9.80	0.86
15	Okmeyd. İETT 7 Katlı Blok	22.50	14.10	5.99	0.39	43.20	3.42	0.47
16	Okmeyd. İETT 7 Katlı Blok	22.50	14.10	5.99	0.37	43.20	3.42	0.44
17	Okmeyd. İETT 7 Katlı Blok	22.50	14.10	5.99	0.37	43.20	3.42	0.44
18	Okmeyd. 2074 Ada, 12 Parsel	27.00	23.00	5.63	0.39	32.50	4.74	0.40
19	Gayrettepe, Özkonak İş H.	24.00	10.00	7.59	0.81	23.00	5.00	0.99
20	Gayr. İş Bank. Koop. A-Blok	38.00	18.00	8.96	0.48	25.00	7.60	0.42
21	Gayr. İş Bank. Koop. B-Blok	46.00	18.00	10.84	0.78	25.00	9.20	0.69
22	Gayr. İş Bank. Koop. C-Blok	27.00	18.00	6.36	0.41	25.00	5.40	0.35

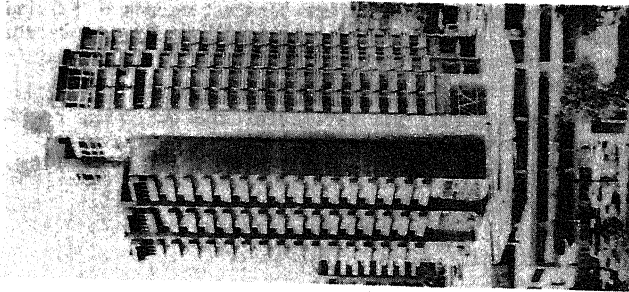


Figure 1 - Harbiye, Yeni Ordnevi Binası, (Army Recreation Building, No. 5 in the above table). The structure is composed of dense and crossing shear walls.

No. 3 and 5, in the table).

On the contrary, some medium-rise buildings have periods, longer than expected (e.g. bldg. No. 7 and 19, in the table). They are structures, composed of slender columns and beams, and are usually lacking the rigidity effect of infill walls.

The plot versus N , exhibits better conformity than H/\sqrt{D} , for a wide variety of structures.

The suggested groups and corresponding coefficients (for the formula $T = e \cdot N$) are given below, as a first approximation. It is believed that different forms of formulae should be fitted to each group and the work is directed to this end. However, the adoption of the following grouping and the utilization of the proposed coefficients in the mentioned formula will greatly improve the degree of accuracy in estimation of the elastic periods of buildings in Turkey.

Group No.	Definition	Coefficient e
I	Thick, dense and crossing r.c. shear walls; large-sectioned columns, if any	0.020-0.029
II	Rather thick columns with thick beams, rigid infill walls or shear walls	0.030-0.044
III	Normal-to-thick sized columns and beams, with some rigid infill walls or shear walls	0.045-0.069
IV	Normal sized columns and beams, with minor effect of rigid infill walls or shear walls	0.070-0.089
V	Slender columns and beams, with flexible floors, with a minimum effect of rigid infill walls or shear walls	0.090-0.130

It is also observed that the slenderness ratio H/D has some increasing effect on the period. It becomes important for ratios greater than 2. It must be considered in deciding on the coefficient, between the given lower and upper values.

ACKNOWLEDGEMENT

The period measurements are made within a research project, sponsored by the Building Research Institute of the Scientific and Technical Research Council of Turkey.

The assistance of Maksut GÖKSU of the Building Research Institute, in the measurement and evaluation is gratefully acknowledged.

The discussions with Dr. H. SANDI and Dr. G. ȘERBANESCU of INCERC, Romania, have been extremely helpful for the author, as they previously conducted an extensive study on buildings in Romania.

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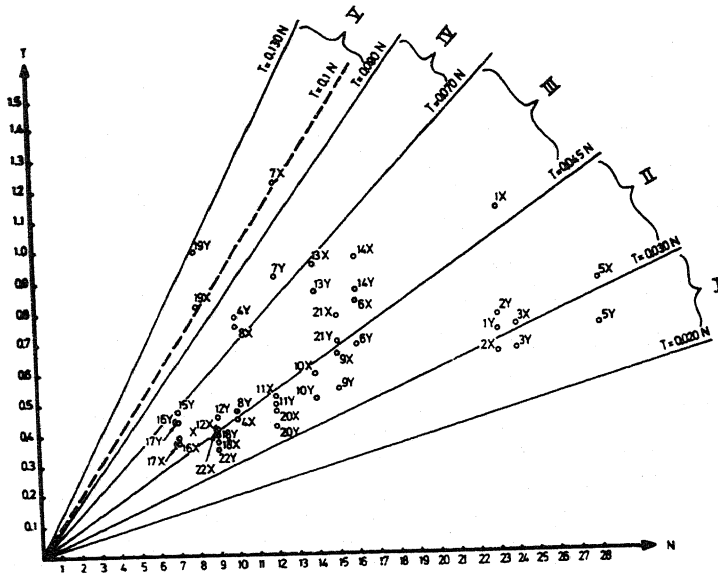


Fig. 2 - PLOT OF PERIODS VERSUS N

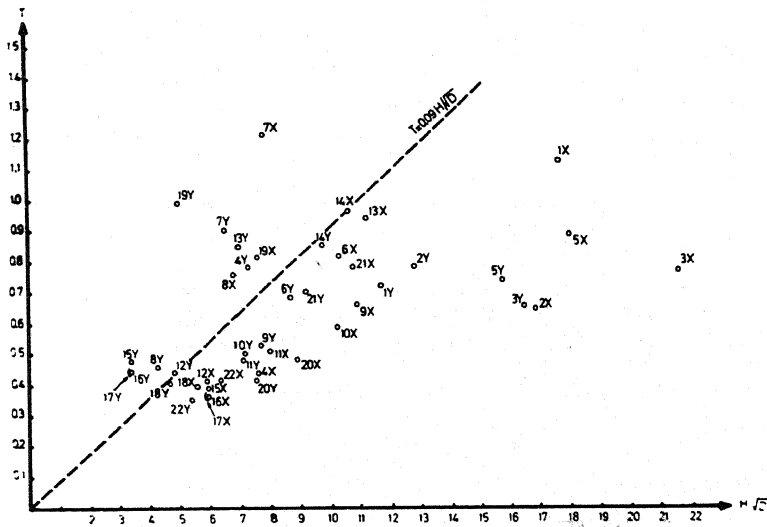


Fig. 3 - PLOT OF PERIODS VERSUS H/D