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A REVIEW OF PART I OF EXPLANATORY HANDBOOK ON CODES FOR EARTHQUAKE ENGINEERING

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ABSTRACT

Part I of the Explanatory Handbook on Codes for Earthquake Engineering published by Bureau of Indian Standards has been critically reviewed. Suggestions are given for enriching contents of the Handbook in its next edition. Some of the solved examples in the handbook require corrections and these are mentioned. Some examples have debatable assumptions and these have been solved by the finite element method to check validity of such assumptions and suitable modifications are suggested. Finally, typographical errors that have not yet been included in the errata available with the handbook are listed in the appendix.

Key Words : Aseismic Design, Code, Earthquake Engineering, Earthquake Resistant Design, Handbook, IS 1893.

INTRODUCTION

Bureau of Indian Standards has done a commendable work in bringing out the Explanatory Handbook for Codes on Earthquake Engineering (hereafter to be referred as the handbook) (Ref. 1). This is so because a majority of practising engineers in the country, like in any other country, lack a formal education in earthquake engineering. Thus, the handbook serves as a very useful tool by (i) explaining some of the concepts used in the relevant codes and (ii) providing examples on how to apply various clauses of the code to a structure being designed. However, the task of preparing such a handbook is not only difficult but also requires input from a large section of end-users. Thus, it is very important that such a handbook should be constantly revised and updated in view of the experience gained on its use.

The handbook deals with two codes, namely IS : 1893-1975 Criteria for Earthquake Resistant Design of Structures (Ref. 2) and IS : 4326-1976 Code of Practice for Earthquake Resistant Design and Construction (Ref. 3). However, IS : 1893 has since been revised and now IS: 1893-1984 is in practice. Thus the handbook, especially its Part I dealing

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with IS: 1893, is due for revision. The present study was made in this context. All the examples of part I of the handbook have been critically reviewed. Solutions to some of the examples need revision and such examples have been worked out here. Besides, suggestions are included for improvement in the contents of this part of the handbook. Typographical errors that have not yet been included in the errata available with the handbook are listed in the appendix.

It is expected that this article will give a useful input at the time of revision of the handbook. Also, it will serve as a useful reference to the practising engineers until the revised edition of the handbook becomes available which may take quite some time.

GENERAL SUGGESTIONS

This section lists some suggestions for overall improvement in contents of the handbook.

(1) There is a misconception among fairly large number of engineers that the storey stiffness of a framed-structure can be obtained by the expression $\Sigma 12\ EI/L^3$, where E is the modulus of elasticity, I is the moment of inertia and L is the length of a column, and the summation is carried out on all the columns of that particular storey. This misconception is further strengthened by two worked out examples in the handbook, viz. Example (2) on the modal analysis of a 15-storeyed R. C. building, and Example (6) on finding out the staging stiffness of an overhead tank.

The above expression is valid only when the beams are rigid as compared to the columns and cannot be applied to these two example structures. It has been shown subsequently in this article that the beams in these structures are in fact quite flexible and thus the structure is much more flexible than the solutions in the handbook indicate. It is therefore recommended that this aspect be brought out very clearly in the next edition of the handbook. One convenient way of incorporating the beam flexibility without having to go for sophisticated computer analysis is given in Ref. (5). The handbook may choose to solve a problem using some such technique and this will be of great assistance to an engineer in following the 'spirit' of the code.

(2) As the handbook has been published by Bureau of Indian Standards, a number of practising engineers tend to rely rather heavily on its contents. It is therefore important that all the assumptions that are made in the analysis be brought out clearly and the user warned adequately on possible situations where such assumptions are not valid and its likely effects on response quantities. For instance, in Example (2), storey stiff

ness calculations ignore the rigid parts of columns at either ends due to presence of beams of finite depth. This can be quite significant if beam depth is large.

(3) Some of the parameters required for seismic analysis can be quite subjective. The handbook should give some brief description of these and guide the user by indicating the practice usually followed or the relevant literature. Modulus of elasticity of concrete and moment of inertia of a concrete column or beam are such quantities. Similarly, in the retaining wall analysis, angle of friction (δ) between wall and earthfill usually puzzles an inexperienced designer. The handbook can guide him by stating what this quantity is and how this value is usually chosen, and can also add that the active pressure calculation is not so sensitive to the chosen value of δ while passive pressure calculation is quite sensitive to δ.

(4) Some examples merely put numbers into the expressions given in the code without making it clear as to how these calculated values are to be used in the design. For instance, in Examples (7) and (8), hydrodynamic pressure variation along the walls and the base of the tank has been calculated. These examples would have been more useful if additional shear, bending moment or axial force developed due to hydrodynamic pressure had also been calculated which can then be directly included in the conventional static design. For this, Housner's mechanical analog model (Ref. 6) can be included in the handbook. It must be mentioned here that expressions for impulsive hydrodynamic pressures in the code are based on the same reference.

(5) Article 5.3 of I.S. : 1893 on stacklike structures gives recommendations regarding period of vibration, base shear and base moment in chimneys on the basis of a parametric study (Ref. 7) The handbook describes various parameters that have been varied in this parametric study This serves no useful purpose The emphasis should be on explaining why some of the coefficients have been included in the formulae given in that article. This part of the code remains difficult to follow because of the following reasons and the handbook should attempt to clarify these.

In the code, base shear is given by $C_v \alpha_h W_t$ and base moment by $\alpha_h W_t \bar{h}$ Here α_h is the design horizontal seismic coefficient W_t is the total weight of the structure, C_v is a coefficient that depends upon slenderness ratio (k) and varies from 1.02 for $k = 5$ to 1.50 for $k = 50$ or more, and $\bar{h}$ is height of centre of gravity of structure above base. Thus, the base shear is obtained by multiplying total weight of the chimney by α_h and C_v where C_v

is always more than one. This gives unusually high value of base shear. On the other hand, base moment is obtained by multiplying $\alpha_h W_t$ by height of centre of gravity of chimney above its base ($\bar{h}$). Thus, not only C_v is not included but also the lever arm has been taken as $\bar{h}$ disregarding the fact that seismic acceleration and hence the force is not constant with height but is more towards the top. Same chimney as of Example (9) of the handbook has been analyzed by finite element method, considering first three modes and using design spectrum of IS 1893—1975. Table (1) gives shear and moment at different locations as obtained by the finite element analysis and the I.S. 1893 provisions. It is obvious that the IS 1893 provisions on chimneys especially those pertaining to shear are too conservative. The handbook will serve a very useful purpose if such provisions and thinking behind them is explained.

(6) In Example (15) of the handbook, active and passive pressures due to a backfill of 12m height are calculated for seismic conditions. In the seismic design of a retaining wall, one considers active pressure due to backfill and passive pressure due to a smaller fill on the other side of the wall. Thus, one need not calculate passive pressure due to a backfill of 12m height on a 12m high wall. This example may create an impression to a user that he must calculate both active and passive pressure due to a backfill and use the higher of the two (which will always be the passive pressure). Instead, the example should show how a retaining wall is checked for stability in seismic conditions due to active pressure of the backfill of 12m height and passive pressure of the much smaller fill on the other side of the wall.

(7) In many instances, some of the parameters used have not been clearly mentioned and have to be back calculated from some other quantity. For instance, modulus of elasticity used in Example (2) has nowhere been mentioned. This must be avoided.

(8) Much has been talked about the seismic response of Earth and Rockfill Dams. But no example is given on such dams in the handbook. It is recommended that an example on the above topic be included in the next edition.

EXAMPLES IN THE HANDBOOK

In this section, errors in some of the examples of the handbook are poi n ted out and a few of them have been worked out again.

Example 1) :

In this example, the lumped load at roof level is taken incorrectly as 313.29 t. But it should be as

$$W_8 = 43\,2 + \frac{23\,04}{2} + 182.\,25 + \frac{64.8}{2}$$

$$+ \text{ zero live load}$$

$= 269.37t$

Because of this, the subsequent values will change. Table (2) of this paper gives correct values for Table (1) of the handbook.

Example (2) :

As mentioned earlier the beams in this example cannot be treated as rigid This example has been analyzed by the finite element method and it is found that fundamental period of the building is 3,091 sec as against 1,042 sec shown in the handbook on the basis of rigid beam assumption. Tables (3) to (8) of this paper give the correct versions of Tables (2) to (7) in the handbook. These values are obtained on the basis of centre - line heights for columns and centre-line spans for beams, thus disregarding the stiff zone in beams and columns at the joints. The natural period will be somewhat lower if this rigidity is also taken into account.

However, even with the rigid beam assumption, the example as presented in the handbook has the following errors :

(a) Values of shear for each storey have been incorrectly calculated except for the top three storeys. Table (9) of this paper gives the correct values of these shears on the basis of seismic forces as calculated in Tables (4), (5), (6) of the handbook. These are the values of shear that should have been obtained in Table (7) of the hand book even with the assumption of rigid beams.

(b) There is a statement on page (15) "It is seen that in a few storeys the drift exceeds $0.004 \times 3 = 0.012$m and hence the design needs revision from this point of view" However, the values of relative displacements in Table (7) of the handbook are in cm units and do not exceed 0.012 m (= 1.2 cm). Hence, this statement needs revision.

Example (3) :

The following points relate to Example (3) of the handbook :

(a) Number of beams has been incorrectly taken as 14, instead of actual 27 beams, in weight calculation.

(b) On page (17), the eccentricity for top floor has been taken more than that of the other floors without assigning any justification. In our opinion, for the given example the top floor eccentricity will be the same as that of all other floors.

(c) Even with the values of eccentricities assumed in the hand book, Tables (9) and (10) of the handbook have errors. Tables (10) and (11) of this paper gives correct values for Tables (9) and (10) of the handbook for eccentricity values taken in the handbook.

Example (5) :

The following points relate to Example (5) of the handbook. On page (19) weight of roof slab per metre run including finishes is given as 0.8t. But the following calculations show that it is 0.62t.

Since the length to breadth ratio of the room is about one, it can be assumed that the entire slab weight is equally distributed to walls on all sides of the room (otherwise the distribution depends on the tributary area of the slab for each wall).
Total weight of slab and finishes

$$=5.0\times4.5\times0.12\times2.4+0\ 24\times5.0\times4.5=11\ 88t$$

Weight per metre length of the wall

$$=\frac{11\ 88}{(5.0+4.5)\times2}$$

$$=0.62t.$$

This example has been reworked out with the assumption that the failure plane in the wall makes an angle of about 45° to vertical on either side of the cantilever (Fig. 1). This is more realistic than the assumption of vertical failure lines made in the handbook.

With reference to figure (2), stabilising moment is given by

$$M_s=W(1-\alpha_v)t/2$$

and overturning moment by

$$M_o=W_1(1+\alpha_v)L/2$$

where

$$\alpha_v=0.2$$

$$W_1=1\times1\times0.06\times2.4=0.144t$$

$$M_o=0.144(1+0.2)\times0.5=0.0864tm$$

Weight of the wall giving stabilising moment

$$=(1.0+3.0)\times\tfrac{1}{2}\times1\times0\ 2\times2\ 0$$

$$=0.8t$$

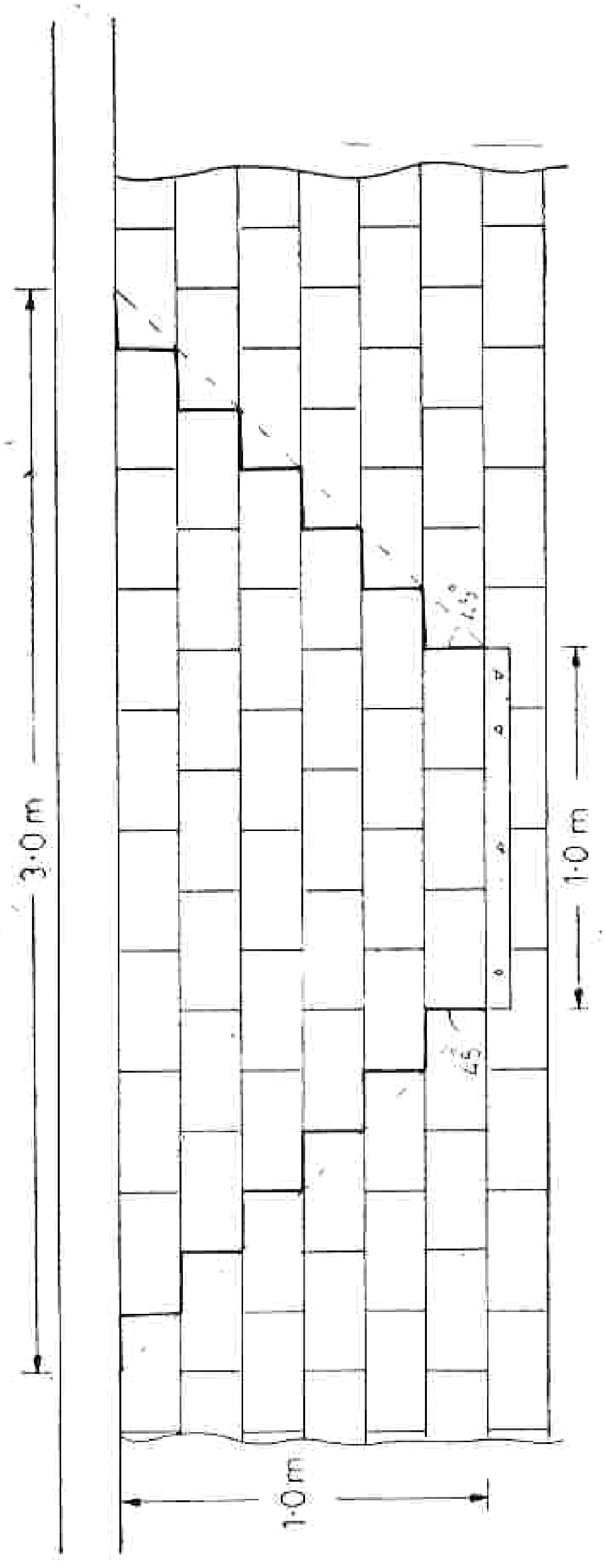

Fig. 1 Assumed Failure Line due to Overturning

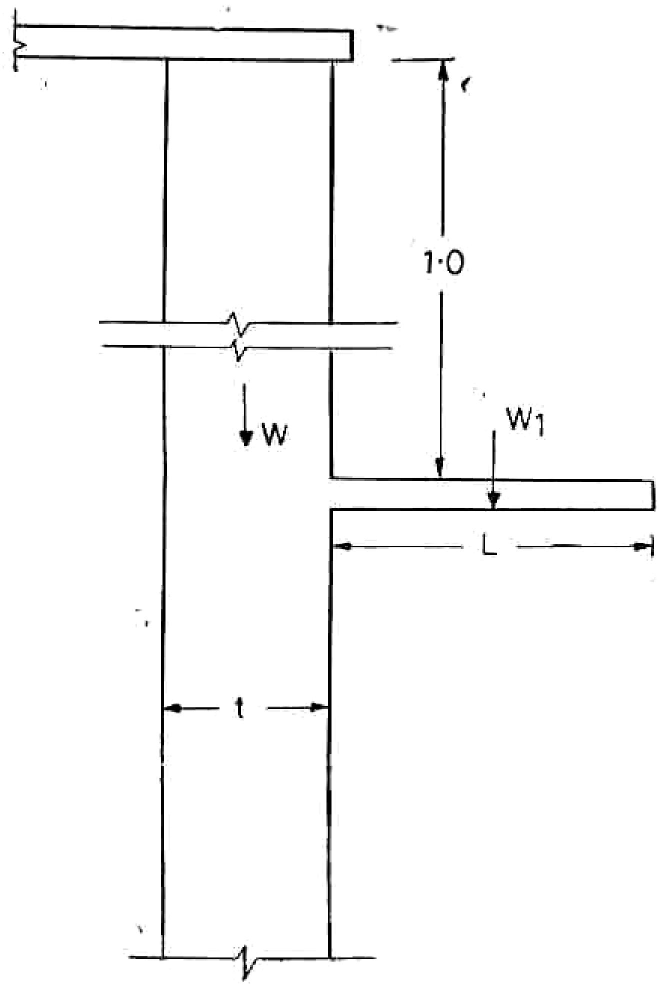

Fig. 2 Schematics of the Horizontal Cantilever

Weight of roof slab per metre length of the wall = 0.62t (obtained earlier)

$W = 0.8 + 0.62$

$= 1.42t$

$M_s = 1.42\ (1-0.2) \times 0.2/2$

$= 0.1136$ t.m.

Factor of safety against

overturning $= \dfrac{0.1136}{0.0864}$

$= 1.31 > 1$

Hence O.K.

Example (6) :

As mentioned earlier, in this example structure also, the beams should not be assumed as infinitely rigid. Assuming the beam size to be 40cm × 40 cm, the staging has been analysed by finite element method and the overall stiffness of the staging (K) is found to be 1520 t/m while that reported in the handbook is 3215.8 t/m. This clearly indicates that the flexibility of the beams is very significant.

Example (10) :

(a) In this example, the design horizontal and vertical seismic coefficients were assumed as 0 05 and 0 0, respectively. However, the vertical seismic coefficient as per art. 3 4.5 of I S : 1893 should be half of the design horizontal seismic coefficient. Thus, α_v should be 0.025.

(b) The coefficient of friction at the movable bearing for steel roller bearings should be 0.03 (Ref. 8) whereas it has been assumed as 0.3.

(c) All possible combinations of direction of horizontal and vertical acceleration should be considered to find the design values of F_1 and F_2 because the same combination does not give maximum values of F_1 and F_2.

This example has been reworked below incorporating all the above modifications.

$W' = 800t \quad e = 6.8 \text{ m} \quad \mu = 0.03$

$\alpha_h = 0.05 \quad L' = 90 \text{ m} \quad \alpha_v = 0.025.$

The condition for maximum value of F_2 (minimum value of F_1) is shown in Figure (3a).

$R_1 + R_2 = 800\,(1-0.025)$

$= 780t$

$90R_2 = 800\,(1-0.025) \times 45 + 800 \times 0.05 \times 6.8$

$R_2 = 393.02t$

$R_1 = 386.98t$

So $F_1 = 0.03 \times 386.98 = 11.61t$

$F_2 = 800 \times 0\,05 - 11.61 = 28.39t$

The condition for maximum value of F_1 is shown in Figure (3b).

$R_1 + R_2 = 800\;(1 + 0.025)$

$= 820t$

$90R_2 = 800\;(1 + 0.025) \times 45 - 800 \times 0.05 \times 6.8$

$R_1 = 413.02t$

$R_2 = 406.98t$

So,

$F_1 = 0.03 \times 413.02 = 12.39t$

$F_2 = 800 \times 0.05 - 12.30 = 27.61t$

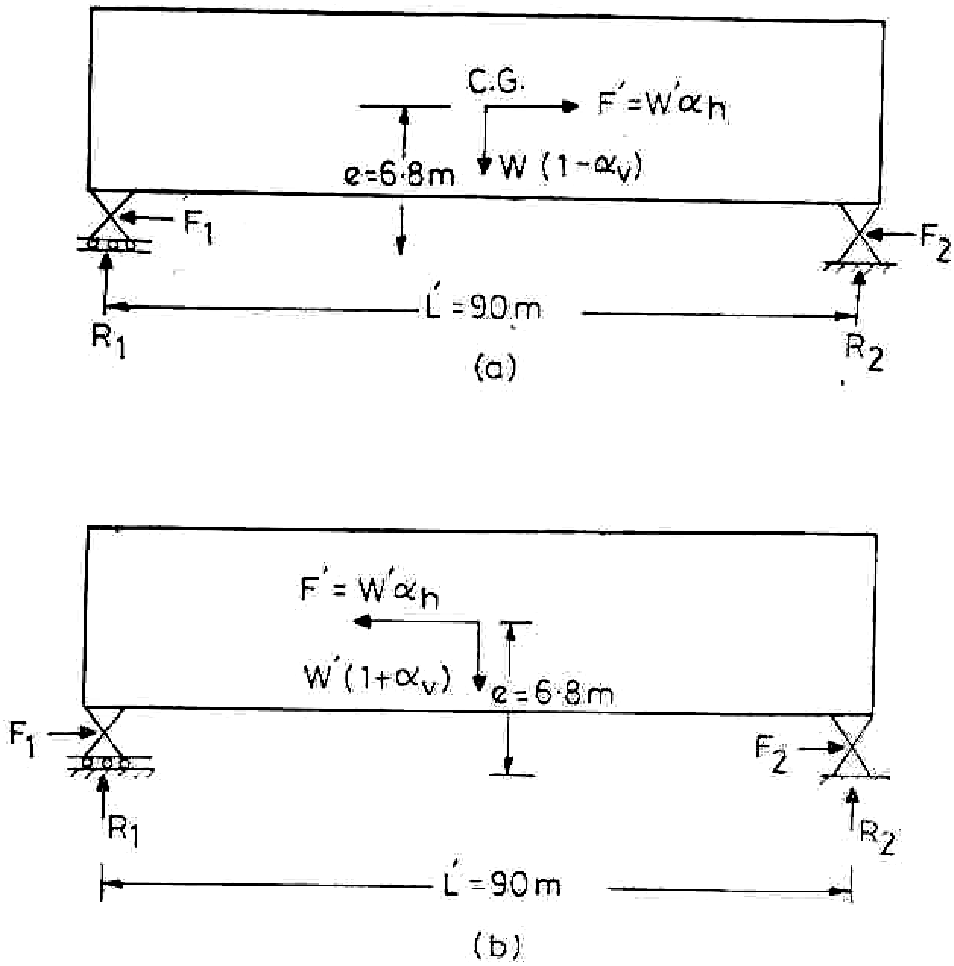

Fig. 3 Schematics of Forces Acting on the Bridge

Comparing values obtained from both the conditions, design values of F_1 and F_2 are
$F_1 = 12.39$t and $F_2 = 28.39$ t

Example (14) :

On page (36) of the handbook, the quantity W_x, weight for height dx (between 10m and base) has been incorrectly obtained as 1.75x dx (the term due to slope of 1 in 20 on upstream face has not been included). It should be

$W_x = 1 \{7 + 0.7 (x-10) + 0.05 (x-10)\}$ dx 2.5
$= (1.875 x - 1.25)$ dx   (1.875 x − 1.25) dx

Now, increase or decrease in weight is

$$= 19.95 + \int_{10}^{100} (1-0.01 x)\ 0.12\ (1.875x-1.25)\ dx$$

$= 19.95 + 358.43$

$= 378.4 \ t$

(instead of 360.15t given in the handbook).

Similarly, in response spectrum method on page (37), increase or decrease in weight at base has been incorrectly calculated as 342.14t. It should be

$$= 18.95 + \int_{10}^{100} (1-0.01x) \ 0.114 \ (1.875x-1.25) \ dx$$

$= 18.95 + 340.50$

$= 359.45t.$

SUMMARY AND CONCLUSIONS

Part I of the Explanatory Handbook for Codes on Earthquake Engineering has been critically reviewed in this paper. As IS 1893-1975 has since been revised, this part of the handbook is due for revision. Thus, it is the right time to review this part on the basis of experience accumulated on use of the handbook for last several years. Suggestions are given for improvements in the content of the handbook, errors have been pointed out in some of the solved examples of the handbook while some others are reworked out in the paper. A list of typographical errors that are not yet included in the errata of the handbook are listed in the appendix. Some of the important suggestions are :

(1) Some simplified procedure must be included in the handbook to calculate storey stiffness of a framed structure while considering beam flexibility.

(2) Emphasis in the handbook should be on explaining various assumptions made in the examples, range of their validity, effects they have on computed quantity and methods for more sophisticated analyses where such assumptions are not required.

(3) The handbook should attempt to encourage use of earthquake-resistant design principles by design engineers by providing complete examples by interfacing seismic forces, etc., with those under static conditions.

(4) There are conceptual and computational errors in many examples and these need be corrected.

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Table 1 : Shear And Moment In The Example Chimney

	Shear		Moment	
Height from base (m)	Finite element analysis (t)	IS : 1893 provisions (t)	Finite element analysis (t—m)	IS : 1893 provisions (t—m)
28 0	0.0	0.0	0.0	0 0
22 4	3.73	6 39	11.22	53.62
16.8	5.93	11.67	38.01	77.70
11 2	7 64	15.84	76.84	103 00
5 6	8 91	18.89	123 08	139.67
0 0	9.39	20.85	174.58	199.37

Table 2 : Nodal Forces and Seismic Shear Forces at Various Levels*

Floor (i)	W_i (t)	h_i (m)	$W_i h_i^2$	Q_i (t)	V_i (shear force) (t)
1	351.26	3	3161.34	0.36	67.66
2	do	6	12645.36	1.43	67.30
3	do	9	28452.06	3.22	65.87
4	do	12	50581.44	5.73	62.65
5	do	15	79033.50	8.95	56.92
6	do	18	113808.24	12.88	47.97
7	do	21	154905.66	17.53	35.09
8	269.37	24	155157.12	17.56	17 56
			597744.72		

* Corresponds to Table (1) of the handbook.

Table 3 : Periods and Mode Shape Coefficients At Various Levels For First Three Modes*

Mode (r)	1	2	3
Period in seconds	3.091	0 999	0.564
Mode shape coefficients at various floor levels			
$\phi_{15}^{(r)}$	1.000	1.000	1 000
$\phi_{14}^{(r)}$	0.984	0 878	0.694
$\phi_{13}^{(r)}$	0.959	0,689	0.256
$\phi_{12}^{(r)}$	0.924	0.438	−0.236
$\phi_{11}^{(r)}$	0 878	0 143	−0 656
$\phi_{10}^{(r)}$	0.823	−0.164	−0 890
$\phi_{9}^{(r)}$	0,758	−0 455	−0 875
$\phi_{8}^{(r)}$	0 684	−0 697	−0.614
$\phi_{7}^{(r)}$	0,603	−0.867	−0.181
$\phi_{6}^{(r)}$	0.515	−0.947	0.303
$\phi_{5}^{(r)}$	0.422	−0.930	0.704
$\phi_{4}^{(r)}$	0.324	−0.817	0.909
$\phi_{3}^{(r)}$	0 224	−0 623	0.866
$\phi_{2}^{(r)}$	0 127	−0.377	0 599
$\phi_{1}^{(r)}$	0 043	−0.132	0.226

* Corresponds to Table (2) of the handbook.

TABLE 4 : Computation of Mode Participation Factor C_1*

Floor No.	Weight (W_i) (t)	Mode shape coefficient (ϕ_1)	$W_i\phi_1$	$W_i\phi_1^2$
1	514.34	0.043	22.12	0.95
2	do	0.127	65.32	8.30
3	do	0.224	115 21	25.81
4	do	0.324	166.65	53.99
5	do	0.422	217.05	91.60
6	do	0.515	264.89	136.42
7	do	0.603	310.15	187.02
8	do	0 684	351.81	240.64
9	do	0.768	389 87	295.52
10	do	0.823	423.30	348.38
11	do	0.878	451.59	396.50
12	do	0.924	475 25	439.13
13	do	0.959	493.25	473.03
14	do	0.984	506.11	498.01
15	392.40	1.000	392 40	392.40
			4644.97	3587.70

$$C_1 = \frac{4644,97}{3587.70} = 1.295^{**}$$

* Corresponds to Table (3) of the handbook.

** One can similarly obtain $C_2 = -0.464$

and $C_3 = 0.295$

TABLE 5 : Computation of Lateral Forces and Shears (First Mode)*

Floor No. (i)	Weight (W_i)	Mode shape coefficient $\phi_i^{(1)}$	$C_i\,\alpha_h^{(1)}$	$Q_i^{(1)} = C_i\,\alpha_h^{(1)}\,W_i\,\phi_i^{(1)}$ (t)	$V_i^{(1)} = \Sigma\, Q_i^{(1)}$ (t)
1	514.34	0.043	1.295×0.016	0.46	96.26
2	do	0.127	do	1.35	95.80
3	do	0.224	do	2.39	94.45
4	do	0.324	do	3.45	92.06
5	do	0.422	do	4.50	88.61
6	do	0.515	do	5.49	84.11
7	do	0.603	do	6.43	78.62
8	do	0.684	do	7.29	72.19
9	do	0.758	do	8.08	64.90
10	do	0.823	do	8.77	56.82
11	do	0.878	do	9.36	48.05
12	do	0.924	do	9.85	38.69
13	do	0.959	do	10.22	28.84
14	do	0.984	do	10.49	18.62
15	392.40	1.000	do	8.13	8.13

* Corresponds to Table (4) of the handbook.

Table : 6 Computation of Lateral Forces and Shears (Second Mode) *

Floor No. (i)	Weight (W_i) (t)	Mode shape coefficient ϕ_i (2)	$C_2\alpha_h$(2)	$Q_i(2)=C_2\alpha_h(2) W_i\phi_i(2)$ (t)	$V_i=\Sigma Q_i(2)$ (t)
1	514.34	-0.132	-0.464 × 0.0432	1.36	31.94
2	do	-0 377	do	3.89	30.58
3	do	-0.623	do	6.42	26.69
4	do	-0.817	do	8.42	20.27
5	do	-0.930	do	9.59	11.85
6	do	-0.947	do	9.76	2.26
7	do	-0.867	do	8.94	- 7.5
8	do	-0.697	do	7.19	-16.44
9	do	-0.455	do	4 69	-23.63
10	do	-0.164	do	1.69	-28.32
11	do	0.143	do	-1.47	-30.01
12	do	0.438	do	-4.52	-28.54
13	do	0.689	do	-7.10	-24.02
14	do	0.878	do	-9.05	-16.92
15	392:40	1.000	do	-7.87	-7.87

* Corresponds to Table (5) of the handbook.

TABLE 7 : Computation of Lateral Forces and Shears (Third Mode)*

Floor No. (i)	Weight (W_i) (t)	Mode shape coefficient $\phi_i^{(3)}$	$C_3 a_h^{(3)}$	$Q_i = C_3 a_h^{(3)} W_i \phi_i^{(3)}$ (t)	$V_i = \Sigma Q_i^{(3)}$ (t)
1	514.34	0.226	0 295 × 0.0604	2.07	17.12
2	do	0.599	do	5.49	15.05
3	do	0.866	do	7.94	9.56
4	do	0.9u9	do	8 33	1.62
5	do	0.704	do	6.45	-6.71
6	do	0 303	do	2.78	-13 16
7	do	-0 181	do	-1.66	-15 94
8	do	-0 614	do	-5.63	-14 28
9	do	-0.875	do	-8 02	-8.65
10	do	-0 890	do	-8 16	-0.63
11	do	-0 656	do	-6 01	7.53
12	do	-0.236	do	-2.16	13 54
13	do	0.256	do	2.35	15.70
14	do	0.694	do	6.36	13.35
15	392.40	1.000	do	6 99	6.99

* Corresponds to Table (6) of the handbook

Table 8 : Drift or Maximum Interstorey Displacement of Building*

Storey (i)	shear V_i (t)	Stiffness K_i (t/cm)	Maximum relative displacement V_i/K_i (cm)
1	117.72	350 0	0.336
2	115 59	250 0	0 462
3	109.84	250.0	0.439
4	101.16	250.0	0.405
5	95 78	250 0	0.383
6	90.19	250.0	0.361
7	88.09	250.0	0.352
8	85.03	250.0	0.340
9	79.26	250.0	0 317
10	71.29	250.0	0.285
11	67.10	250.0	0.268
12	60.74	250.0	0.243
13	50.44	250.0	0 202
14	35.62	250.0	0.142
15	16.69	150.0	0.111

* Corresponds to Table (7) of the handbook

Table 9 : Drift or Maximum Interstorey Displacment of Building With Rigid Beam Assumption*

Storey i	Shear V_i (t)	Stiffness K_i (t/cm)	Maximum relative displacement V_i/K_i (cm)
1	293.78	1804.80	0.163
	(391.37)**		(0.217)**
2	287.26	do	0.159
	(382.93)		(0.212)
3	273.75	do	0 152
	(367.19)		(0.203)
4	259.60	do	0.144
	(346.10)		(0.192)
5	246.08	do	0.136
	(321.95)		(0.178)
6	233.78	do	0.129
	(296.95)		(0.165)
7	224 31	do	0.124
	(272.81)		(0.151)
8	210 51	do	0.117
	(245.96)		(0.136)
9	192.45	do	0.107
	(217.14)		(0.120)
10	173.13	do	0.096
	(188.17)		(0.104)
11	154.79	do	0.086
	(161.08)		(0.089)
12	131.67	do	0.073
	(132.71)		(0 074)
13	103.03	do	0.057
	(103.03)		(0 057)
14	68.98	do	0.038
	(68.98)		(0.038)
15	30.73	do	0 017
	(30.73)		(0.017)

**Values given in Table (7) of the handbook are shown within parantheses.

*Corresponds to Table (7) of the handbook

Table 10 : Torsional Shears In Various Storeys In X-Direction (In Tonnes)*

Column line	First storey (1) V_x	Second storey (2) V_x	Third storey (3) V_x	Fourth storey (4) V_x
1	0.208	0.201	0.172	0 132
2	0.052	0.050	0.043	0.033
3	—0.104	—0.101	—0 086	—0.066
4	—0.156	—0.151	—0.129	—0.099

*Corresponds to Table (9) of the handbook.

Table 11 : Torsional Shears In Various Storeys In Y-Direction (In Tonnes)*

Column line	First storey (1) V_y	Second storey (2) V_y	Third storey (3) V_y	Fourth storey (4) V_y
A	0 516	0.498	0.425	0 379
B	0.234	0.226	0.193	0.172
C	—0.047	—0.045	—0.039	—0.034
D	—0.246	—0.238	—0 203	—0.181
E	—0.457	—0.441	—0.377	—0.336

*Corresponds to Table (10) of the handbook.

APPENDIX

List of Typographical Errors In Part I of The Explanatory Handbook On Codes For Earthquake Engineering

(Excluding Those Given In Errata Or The Handbook

(Page 5, informal table, heading)— Read' PRESSURE OR RESISTANCE ... .. 'for'...... PRESSUREO R RESISTANCE .....'

(Page 6, Col. 1, line 13)—Substitute 'ground shaking' for 'ground, shaking'

(Page 11, Col. 1, lines 10 and 16) — Substitute 'weight' for 'mass'

(Page 11, Col. 1, line 12) — Insert '+37.97' between '+64.8' and '='

(Page 11, Col. 1, line 32) — Substitute 'Figure 3' for 'Table 3'

(Page 11, Col. 2, line 22) — Substitute 'in' for 'is'

(Page 12, Col. 1, lines 34—36) — Read "The equation of motion for free vibration of a multi-storeyed lumped mass (undamped) system can be written as : " for "The equation of motion for a freely vibrating motion of a multi-storeyed lumped mass (undamped) can be written as:"

(Page 12, Col.1, line 40) — Interchange '$\ddot{X}$' and 'X'

(Page 12, Col. 2, line 29) — Substitute 'distribution as weighting' for 'distribution a weighting'

(Page 14, Table 4, Col. 4) — Substitute '3.57×0.042' for '0.150×0 042'

(Page 14, Table 4, Col. 5, line 4) — Substitute '11.03' for '40.93'

(Page 14, Table 5, Col. 4)—Substitute '1.18×0.0737' for '0.087×0.0737'

(Page 14, Table 6, Col. 4) —Substitute '0.698×0.080' for 0.056×0.080'

(Page 14, Table 6, Col. 4) — Substitute 'C_3' for 'C_1'

(Page 15, Fig. 4) — Include 'O' (oh) at left bottom corner of the figure

(Page 16, Col. 2, line 1) — Substitute 'O' (oh) for '0'

(Page 16, Col. 2, line 10) — Read '$I_{xy} = \sum [K_x y^2 + K_y x^2]$ for '$I_{xy} = \sum [K_x Y^2 + K_y X^2]$

(Page 16, Col. 2, lines 4 and 3 from bottom) — Substitute 'live load 300 Kg/m^2 'for 'load 200 kg/m^2'

(Page 17, Col. 1, line 13) — Substitute '(22.5+15+...)' for '(22.5×15 +...)'

(Page 17, Col.1, line 26) — Substitute '0.4 s' for '0.5 s'

(Page 36, Col. 2, line 18)—Substitute 'length' for 'width'

(Page 36, Col. 2, line 21)—Substitute '$\alpha_x W_x$' for '$\alpha_x W_x\, dx$'

(Page 37, Col. 1, lines 26 and 27)—Substitute 'statics' for 'statistics'

(Page 42, Col. 2, line 19)—Substitute '0.982' for '0 892'

(Page 42, Col. 2, line 20)—Substitute '0.766' for '0.776'

(Page 43, Col. 2. lines 6 and 18) —Substitute' . +5 ' for '.. +15 '.