Volume IV **Number I**

Bulletin of the Indian Society of Earthquake Technology

EDITOR L. S. SRIVASTAVA

JANUARY, 1967

CONTENTS

BULLETIN OF THE INDIAN SOCIETY OF EARTHQUAKE TECHNOLOGY

Aims and Scope

The Indian Society of Earthquake Technology was founded in November 1962 at the request of the Participants of the Second Symposium on Earthquake Engineering held in Roorkee, India, with the aim of advancing knowledge of the earthquake technology in all aspects.

The Bulletin of the Indian Society of Earthquake Technology, covering all aspects of earthquake technology presents a cross section of technical papers, reviews, comments and discussions in the field of earthquake technology, news of the Society, serving as a medium for recording recent research and development work.

Publication

The *Bulletin of the Indian Society of Earthquake Technology* was first issued in 1964 and has continued as a half yearly publication during the last three years. All back numbers of the *Bulletin*, except the first issue, are still available from the Secretary, and are sold at Rs. 7.50 (Foreign US $ 2.00) a copy.

It is proposed to issue the *Bulletin* as a quarterly publication of the Society from 1967.

Subscription

A subscription to the *Bulletin* is included in membership dues. The subscription rate for non-members is Rs. 30.00 (Foreign UL $ 8.00) a year. Forms for membership application and for subscriptions can be had from the Secretary.

Commnnications

Change of address notices, subscriptions, renewals, and communications regarding back numbers, missed number and membership should be addressed to the Secretary.

Manuscripts offered for publication should be submitted to the Editor. A brief abstract must accompany each manuscript. Reprints, if desired by authors (25 reprints are issued free to those authors who are members of the Society), must be ordered at the time the acceptance for printing of the manuscript is communicated to the authors. Reprints are supplied at the rate of 25 paise (Foreign US 5 cents) per reprint with a minimum charge of Rs. 10.00 (Foreign US $ 2.00).

Printed by | Gautam Printing Press, Roorkee, (U.P.)

INDIAN SOCIETY OF EARTHQUAKE TECHNOLOGY
ROORKEE, U. P. INDIA

PROPOSAL FOR MEMBERSHIP

I propose* that ______________________________

be admitted as a Member of the Society. For full details see below.

____

(Member ISET)

No. ________

I second the above proposal of admission of ______________________________ as a Member of the Society.

____

(Member ISET)

No. ________

DECLARATION BY THE NOMINEE

I hereby declare that I will abide by the Statues and Regulations of the Society and offer my cooperation in promoting its objects. My particulars are given in the following.

Date ______________ Signature ______________

1, Name in full (Block letters) ______________________________

2. Address ______________________________

____

3. Profession and present appointment ______________________________
4. Date of birth (Note : True copy of H. School Certificate or any other proof of age to be attached) ______________________________

5. Academic and Technical qualification ______________________________

6. Societies and Institution of which already a number (i) ______________________________

(ii) ______________________________

Note :— 1. Mail to the Secretary, Indian Society of Earthquake Technology, Roorkee, U.P. India.

2. Use blank paper if proforma is not available.

3. * If an ISET member is not locally available, please send the form to Secretary along with true copies of proof of age and qualifications.

Bulletin of the Indian Society of Earthquake Technology. Vol. 4, No. 1, pp. 1-5. January, 1967

Bulletin of the
Indian Society of Earthquake Technology

Vol. 4 | January, 1967 | No. 1

BEAM VIBRATIONS BY METHOD OF INITIAL PARAMETERS

A. H. Shah* and Y.C. Dass†

Summary

Method of initial parameter, originally developed for static problems is extended to solve the initial value and forced vibration problems of beams. Two examples are worked out. This method is particularly useful in cases of concentrated forces and moments, and time dependent boundry conditions.

Introduction

Analysis of beam vibrations due to initial conditions as well as due to external exciting forces is a classical one. Vibration problem can be analysed both by method of separation of variables and oprational methods, where natural frequencies are obtained through a characteristic equation, and then the corresponding mode shapes are found. Using the orthoganality property, that exists, among mode shapes, initial value broblem as well as forced vibration problem can be solved.

In this paper, method of initial parameters, originally developed for static problems (1, 2)** is extended to beam vibration problems. Applying Laplace transform to Euler-Bernoulli equation, the equation governing the beam vibration is reduced to contain only the space variable. This transformed equation along with the transformed initial and boundary conditions is sol ved by the method of initial parameters. The inverse transform then gives the complete solution.

Method of Analysis

The Euler-Bernoulli equation governing the transverse vibration of a uniform beam is

$$E I \frac{\partial^4 w}{\partial x^4}(x, t) + m \frac{\partial^2 w}{\partial t^2}(x, t) = q(x, t). \tag{1}$$

Where

$E I$ = flexural rigidity of a beam
m = mass per unit length
$w(x, t)$ = transverse deflection
$q(x, t)$ = is the external exciting force

The initial condition are

$$w(x, o) = y_0(x) \quad ; \quad \left.\frac{\partial w}{\partial t}\right|_{t=o} = \dot{y}_0(x). \tag{2}$$

* Assistant Professor, Department of Civil Engineerin, Indian Institute of Technology, Kanpur.
† Associat Professor, Department of Civil Engineering, Indian Institute of Technology, Kanpur.
** Numbers in brackets designate references at end of paper.

The beam has four boundry conditions, two at each end. There may be any combination of hinged, clamped, free and elastic supports. Taking the Laplace transform of equation (1), we obtain

$$\frac{d^4 \overline{W}}{d x^4}(x, s) + \frac{m}{EI} s^2 \overline{W}(x, s) = \frac{\overline{q}}{EI}(x, s) + \frac{m}{EI} s\, y_o(x) \frac{m}{EI} \dot{y}_o(x) \quad (3)$$

where $\overline{g}(x, s) = \int_0^{\infty} g(x, t)\, e^{-st}\, dt$ and s is a transformed parameter.

The solution of the homogeneous part of this equation (3) is

$$\overline{W}(x, s) = A \sin \beta x + B \cos \beta x + C \sinh \beta x + D \cosh \beta x. \quad (4)$$

where $$\beta^4 = -\frac{m}{EI} s^2 . \quad (5)$$

Define the initial parameters as follows :

$$\begin{aligned} \overline{W}(o, s) &= \overline{W}_o(s) \\ \overline{\theta}(o, s &= \overline{W}'(o,s) = \overline{\theta}_o(s) \\ \overline{M}(o, s) &= -EI\, \overline{W}''(o, s) = \overline{M}_o(s) \\ \overline{V}(o, s) &= -EI\, \overline{W}'''(o, s) = \overline{V}_o(s), \end{aligned} \quad (6)$$

where prime indicates derivative with respect to x. Using the equation (6) the four constants A, B, C and D in equation (4) can be found in terms of initial parameters $\overline{W}_o$, $\overline{\theta}_o$, $\overline{M}_o$ and $\overline{V}_o$. The equation (4) in terms of initial parameters will be

$$\overline{W}(x, s) = \overline{W}_o f_1(\beta x) + \frac{\overline{\theta}_o}{\beta} f_2(\beta x) + \frac{\overline{M}_o}{EI \beta^2} f_3(\beta x) + \frac{\overline{V}_o}{EI \beta^3} f_4(\beta x), \quad (7)$$

where

$$\begin{aligned} f_1(\beta x) &= \tfrac{1}{2}(\cos \beta x + \cosh \beta x) \\ f_2(\beta x) &= \tfrac{1}{2}(\sin \beta x + \sinh \beta x) \\ f_3(\beta x) &= \tfrac{1}{2}(\cos \beta x - \cosh \beta x) \\ f_4(\beta x) &= \tfrac{1}{2}(\sin \beta x - \sinh \beta x). \end{aligned} \quad (8)$$

Case 1 : Beam having a concentrated load P (t) at $x = \xi$. (Figure 1). Since we know two of the four initial parameters at $x = 0$, there will remain only two unknown parameters in equation (7). For the range $0 \leq x < \xi$ the equation (7) holds good as there is no transverse load on the beam. We can write

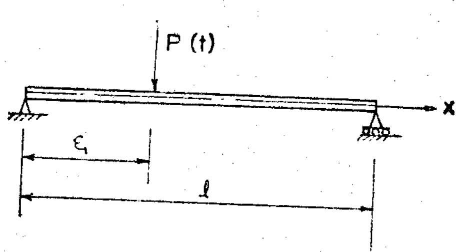


FIG. 1

$$\overline{W}_1(x, s) = \overline{W}(x, s) \qquad 0 \leq x < \xi \quad (9)$$

Since we have a concentrated load at $x=\xi$ we can consider this as a jump in shear and write down the shear condition as

$$\overline{v}(\xi, s) = -\overline{P}(s). \quad (10)$$

For the range $\xi < x \leq l$, $\overline{W}(x, s) = \overline{W}_1(x, s) + \overline{W}_2(\bar{x}, s)$ (11)

where $w_2(\bar{x}, s)$ represents the additional deflection due to the jump in shear given in equation (10), and $\bar{x} = x - \xi$.

To find $\overline{W}_2(\bar{x}, s)$, let us imagine a fictitious beam for the range $\xi < x \leq l$.

For this beam the following are the initial parameters :

$$\begin{aligned} \overline{W}_2(o, s) &= 0 \\ \overline{\theta_2}(o, s) &= 0 \\ \overline{M}_2(o, s) &= -EI\,\overline{W}_2''(o, s) = 0 \\ \overline{V}_2(o, s) &= -EI\,\overline{W}_2''' = -\overline{P}(s). \end{aligned} \tag{12}$$

$\overline{W}_2(\bar{x}, s)$ is in the form of equation (7) except instead of x we have $\bar{x}$. Using equation (12), we obtain

$$\overline{W}_2(\bar{x}, s) = -\frac{\overline{P}(s)}{EI\beta^3} f_4(\beta\bar{x}). \tag{13}$$

Hence, the complete solution, equation (11), can be written as

$$\overline{W}(x, s) = w_o f_1(\beta x) + \frac{\overline{\theta_o}}{\beta} f_2(\beta x) + \frac{\overline{M}_o}{EI\beta^2} f_3(\beta x) + \frac{\overline{V}_o}{EI\beta^3} f_4(\beta x) - \frac{\overline{P}(s)}{EI\beta^3} f_4(\beta\bar{x}). \tag{14}$$

The remaining two parameters can be found from the transformed boundary conditions at x=l. Taking the inverse Laplace transform of equation (14), we can obtain the required solution w (x, t).

Case 2 : Beam having a concentrated moment $M_c(t)$ at $x=\xi$. (Figure 2). In this case there is a jump in moment at $x=\xi$. Following in a similar manners as Case 1 solution can be obtained as

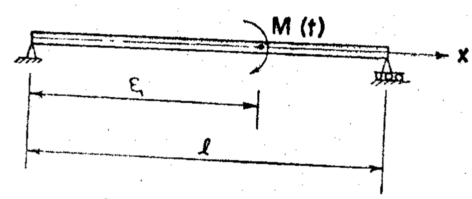


FIG. 2

$$\overline{W}(x, s) = \overline{W}_o f_1(\beta x) + \frac{\overline{\theta_o}}{\beta} f_2(\beta x) + \frac{\overline{M}_o}{EI\beta^2} f_3(\beta x) + \frac{\overline{V}_o}{EI\beta^3} f_4(\beta x) - \frac{\overline{M}_c(s)}{EI\beta^2} f_3(\beta\bar{x}). \tag{15}$$

Case 3 : Beam subjected to arbitary load of intensity Q (x, t). (Figure 3).

In this case we can take

$$\overline{P}(s) = \overline{Q}(\xi, s)\, ds \text{ at } x=\xi \text{ and } l_1 \leq \xi \leq l_2 .$$

Following in a similar manner as Case 1, we can write

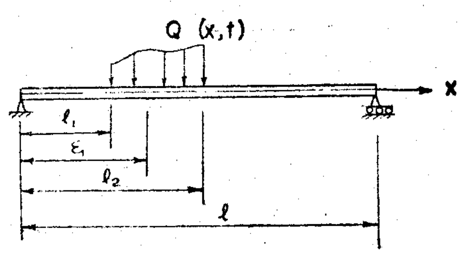


FIG. 3

$$\overline{W}(x, s) = \overline{W}_o f_1(\beta x) + \frac{\overline{\theta_o}}{\beta} f_2(\beta x) + \frac{\overline{M}_o}{EI\beta^2} f_3(\beta x) + \frac{\overline{V}_o}{EI\beta^3} f_4(\beta x) - \frac{1}{EI\beta^3}\int_{l_1}^{x} \overline{Q}(\xi, s) f_4(\beta\bar{x})\, d\xi. \tag{16}$$

Considering $\overline{Q}(\xi,s) = \frac{\overline{q}}{EI}(\xi, s) + \frac{ms}{EI} y_o(\xi) + \frac{m}{EI}\dot{y}_o(\xi)$, equation (16) represents solution to initial value problem as well as forced vibration problem.

Example 1 : Forced–vibration of a simply supported beam with a time dependent load at an arbitary point on the beam.

In this case the initial displacement and initial velocity of the beam are taken as zero [i.e., $y_o(x) = \dot{y}_o(x) = 0$].

The solution for this problem is given by equation (14) with the follewing values of the initial parameters.

$$\begin{aligned} \overline{W}_0 &= 0 \\ \overline{M}_0 &= 0 \\ \overline{\theta_0} &= \frac{\overline{P}(s)}{EI\beta^3}\left\{\frac{f_4(\beta \bar{l})\, f_2(\beta l) - f_3(\beta \bar{l})\, f_4(\beta l)}{f_2^2(\beta l) - f_4^2(\beta l)}\right\} \\ \overline{V}_0 &= \overline{P}(s)\left\{\frac{f_2(\beta l)\, f_2(\beta \bar{l}) - f_4(\beta l)\, f_3(\beta \bar{l})}{f_2^2(\beta l) - f_4^2(\beta l)}\right\} \end{aligned} \tag{17}$$

Substituting equation (17) into equation (14), the transformed deflection is given by

$$\overline{W}(x,s) = \frac{\overline{P}(s)}{2EI} \cdot \frac{1}{\beta^3}\left\{\frac{\sin\beta\xi \sin\beta(l-x)}{\sin\beta l} - \frac{\sinh\beta\xi \sinh\beta(l-x)}{\sinh\beta l}\right\} \tag{18}$$

After taking inverse Laplace transform of equation (18), the deflection is given by

$$w(x,t) = \int_0^t P(t-\tau)\, F(\tau)\, d\tau \tag{19}$$

where

$$F(t) = \sum_{n=1}^{\infty} \frac{2}{m\, l\, \omega_n} \sin\frac{n\pi\xi}{l} \cdot \sin\frac{n\pi x}{l} \cdot \sin\omega_n t \tag{20}$$

and

$$\omega_n = n^2 \pi^2 \sqrt{\frac{EI}{m l^4}} \tag{21}$$

Taking $P(t) = A_0 \sin \Omega t$, the deflection is given by

$$w(x,t) = \frac{2A_0}{m l} \sum_{n=1}^{\infty} \frac{\sin\frac{n\pi\xi}{l} \cdot \sin\frac{n\pi x}{l}}{\omega_n} \; \frac{\omega_n \sin\Omega t - \Omega \sin\omega_n t}{(\omega_n^2 - \Omega^2)} \tag{22}$$

Equation (22) checks with the value given in Reference [3].

Example 2 : A simply supported beam subjected to prescribed end motion.

Here the boundry conditions are

$$\begin{aligned} w(o,t) &= 0 \\ w''(o,i) &= 0 \\ w(l,t) &= f(t) \\ w''(l,t) &= 0 \end{aligned}$$

The solution is still given by equation (14) without the last term, with the following values of the initial parameters

$$\begin{aligned} \overline{W}_0 &= 0 \\ \overline{M}_0 &= 0 \\ \overline{\theta_0} &= \bar{f}(s) \cdot \frac{\beta f_2(\beta l)}{f_2^2(\beta l) - f_4^2(\beta l)} \\ \overline{V}_0 &= -\bar{f}(s) \cdot EI\beta^3 \frac{f_4^2(\beta l)}{f_2^2(\beta l) - f_4^2(\beta l)} \end{aligned} \tag{23}$$

The transformed deflection is given by

$$\bar{w}(x, s) = \bar{f}(s) \frac{\sin \beta x \sinh \beta l + \sin h\beta x \sin \beta l}{2 \sin \beta l \sinh \beta l} \qquad (24)$$

After the inverse transform, the deflection is given by

$$w(x, t) = \int_0^t f(t-\tau) F(\tau) d\tau \qquad (26)$$

where

$$F(t) = \sum_{n=1}^{\infty} (-1)^{n+1} \frac{2\omega_n}{n\pi} . \sin \frac{n\pi x}{l} \sin \omega_n t \qquad (26)$$

where

$$\omega_n = n^2 \pi^2 \sqrt{\frac{E I}{m l^4}}$$

Taking $f(t) = B_0 \sin \Omega t$, the deflection is given by

$$w(x, t) = B_0 \sum_{n=1}^{\infty} (-1)^{n+1} \frac{2\omega_n}{n\pi(\omega_n^2) - \Omega^2)}(\omega_n \sin \Omega t - \Omega \sin \omega_n t) \sin \frac{n\pi x}{l} \qquad (27)$$

References

1. A. A. Umansky, (1933), "Analysis of Beams on Elastic Foundation", Central Research Institute of Auto-Transportation, Lenningrad.
2. M. Hetenyi, (1961), "Beams on Elastic Foundation", University of Michigan Press.
3. S. Timoshenko, (1954), "Vibration Problems in Engineering". Van Nostrand Company Inc.

4th WORLD CONFERENCE ON EARTHQUAKE ENGINEERING SANTIAGO, CHILE

On behalf of the Executive Committee of the International Association for Earthquake Engineering (IAEE), the Indian Society of Earthquake Technology, invites Engineers and Scientists interested in the field of earthquake Engineering and Seismology to contribute papers to the 4th World Conference on Earthquake Engineering to be held at Santiago, Chile in January, 1969. The papers may be contributed on any of the themes given below :

Theme I : Earthquake Science and Analysis of Response of Structures to Earthquake Ground Motion.

a. Seismicity
b. Instrumentation and Ground Motion Measurements
c. Spectra and Soil Characteristics
d. Response Analysis
e. Research in Earthquake Engineering
f. Linear and Non-Linear Action of Structure

Theme II : Earthquake Resistant Design and Construction Practices.

a. Design Criteria and Codes of Practice
b. Observation of Performance in Earthquakes
c. Materials of Construction for Earthquake-Resistance
d. Design of Low-Rise and High-Rise Buildings
e. Design Considerations in Other Types of Structures
f. Foundations ond Soil-structure Interaction.

All accepted papers will be printed and distributed prior to the opening of the Conference. The tentative dates for submitting the abstracts and full papers are as follows :

Abstract — January 1, 1968.

Full Paper — June 1, 1968.

Those interested can send their papers for the Conference through the Secretary, Indian Society of Earthquake Technology, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee, U.P, or to the Executive Committee of the I.A.E.E. on the following address :

Secretary General,
International Association for Earthquake Engineering,
C/O International Institute of Seismology and Earthquake Engineering,
Building Research Institute,
4-Chome, Hyakunin-Cho, Shinjuku-Ku,
Tokyo, Japan.

The exact dates of the conference and other details would be communicated to the members of the Society as soon as the same are received from the I.A.E.E.

Bulletin of the Indian Society of Earthquake Technology Vol. 4, No. 1, pp. 7–12 January, 1967

SEISMIC DESIGN OF TALL BUILDINGS-USE OF SHEARWALLS

S.M.A. Kazimi*

Synopsis

The importance of shearwalls or shear panels to increase the lateral stiffness of tall buildings is well known. However, the structural and aesthetic requirements as considered by the engineer and the architect are quite often contrary to each other, and a shear-wall may be entirely absent where it is most needed. Thus the usual design methods assuming a uniform and systematic distribution of shear-walls in each storey are rather impractical A unified method capable of incorporating the stiffness of shear-walls and other stiffening elements like floor slabs and cladding, at their actual location is needed for a realistic analysis of practical shear-wall buildings. In the following pages an attempt is made to present outline of a similar method.

Introduction

Recently there has been a considerable increase in the number of tall buildings, both residential and commercial, because of certain advantages of 'circulation', 'land utilization' and 'planned development' etc. Structural frames of steel or reinforced concrete are generally used and are quite efficient where the lateral forces like wind loads or seismic actions are insignificant. However, in a highly seismic zone due consideration for lateral forces is necessary.

The inherent weakness of structural frames under lateral loads[1], can be easily removed by inserting shear-wall or shear-panels in the building at suitable locations. The advantages of shear-walls as primary lateral load resisting elements for seismic structures was first recognised by Benjamin and Williams[2] of Stanford University in 1948. Since then many workers in U S.A., U.K., U S.S.R., aud Japan have tried to present a theoretical or experimental solution to the problem with varying success. However, a generalised comprehensive solution has not been presented so far.

Previous Work

The utility of shear-walls in tall buildings can not be over emphasised. However, the usual objections to the use of shear-walls in a building frame are, that:

(1) Theoretical analysis of shear-panels and their stiffness factors for various boundary conditions are not adequately known.

(2) Very often the architect may not provide a shear-wall where it is most needed or he may pryvide openings in it to weaken it considerably.

Most of the research workers have treated the shear-wall building as a cantilever and their analysis suffers from excessive idealization. For example Martin Schulz[3] has analysed a multistorey shear-wall with a row of identical openings in each storey, by considering it as a pair of beams with elastic connections. A second degree differential equations of the form.

$$\frac{\partial^2 N}{\partial x^2} - \alpha^2 N = \beta M \qquad (1)$$

is obtained where

N = The shear force in connecting beams at each story.

M = Bending moment in the shear-walls.

*Assistant Professor, Department of Civil Engineering Regional Engineering College Srinagar–6 (Kashmir).

1, 2, 3, ... Refer the serial number of references given at the end.

α, β=Constants, depending on the elastic properties of shear-walls and connections. The solution obtained is of the form,

$$N = A \cosh \alpha x + B \sinh \alpha x + \frac{\beta}{a^2} M_0 + \frac{\beta}{a^4} M_0'' \quad (2)$$

Other workers like Eriksson[4] and Beck[5] adopt similar procedure with some modifications.

The limitations of this procedure are obvious. Apart from the question of considering a 3-dimensional structure as a one dimensional element, it is assumed that all the openings are similar and uniformly spaced. Thus for a normal building with unsymmetrial walls and openings the theory is not applicable.

New Techniques for Isolated Shear Panels

The governing equations for the shear-wall problem in the simplest form are:

$$\left.\begin{aligned}
&\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} = 0 \\
&\frac{\partial \tau_{xy}}{\partial x} + \nu \frac{\partial \sigma_x}{\partial y} + E \frac{\partial^2 v}{\partial y^2} = Pg \\
&\frac{\partial u}{\partial x} + \nu \frac{\partial v}{\partial y} - \frac{(1-\nu^2)}{E} \sigma_x = 0 \\
&\frac{\partial \sigma}{\partial x} + \frac{\partial u}{\partial y} - \frac{2(1+\nu)}{E} \tau_{xy} = 0
\end{aligned}\right\} \quad (3)$$

Where σ_x and τ_{xy} are the direct and shear stresses and u, v are the displacements in x and y directions. Exact solution of these partial differential equations with practical boundary conditions is nearly impossible to achieve. Classical methods like 'conformal mapping techniques' and 'Galerkin' or 'Kantorovich' methods have been tried without much success. Hences a search was made for new methods and various mathematical and semi-equivalent methods tried. Finally the following two methods, termed as 'Line Solution' and 'Grid Analysis' were developed for general application.

Line Solution Techniques

Details of the Line solution techniques has been presented earlier[6,7]. Briefly speaking it is a semi-exact mathematical method for the solution of linear partial differential equations with constant coefficients, having two-point boundary conditions. The 'n'th order governing partial differential equation of any two-dimensional structure is rendered unidirectional by dividing the structure into a number of strips by a series of 'm' lines parallel to, say the 'x' axis, and replacing all the y-derivatives with their finite difference equivalents. This gives a set of 'm' ordinary differential equation of 'n' th order which in turn are reduced to a set of 'mn' first order equations by the use of a new set of variables as:

$$\frac{d F_{k,j}}{dx} F_{k,j+1} \quad (k = o, 1, 2, \ldots m-1; j = o, 1, 2, \ldots n-2) \quad (4)$$

In matrix form the set may be represented as:

$$\frac{d F}{d x} = \underline{A}\ \underline{F} + \underline{B} \quad (5)$$

Where $\underline{A}$ is a square matrix of size (mn × mn) and $\underline{F}$ and $\underline{B}$ are conformable column matrices. This matrix differential equation is solved by 'matrix progression' method and standard computer programmes are made available.

Grid Analysis

This is an equivalent method [8,9] for the solution of general plane-stress problems and and consists of replacing the actual 2-dimensional structure by a hypothetical structure with one dimensional elements, to form a grid work. Conditions of equilibrium and compatibility are approximately satisfied by specifying desired areas and moments of inertia to the members of this grid. However, this is the only approximation made in this analysis. The resulting grid is exactly solved by the stiffness method and a standard programme for the Ferranti Pegasus computer has been developed. The accuracy of the results obtainable by this method is comparable to any of the so called exact methods.

A Generalized Method of Analysis

The difficulties mentioned earlier have to be considered first and their successful solution would form the basis of the new theory. The problem will be studied in two stage i.e. the analysis of isolated single storey shear-walls and the analysis of general multistorey, multi-bay shear-wall buildings.

Analysis of Single Storey Shear-walls

A detailed study of this stage of the problem has been successfully done using these methods. Briefly speaking the following cases were considered:—

a. A shear-wall on a rigid base, under a uniform lateral load.

b. A shear-wall on an elastic base under a uniform lateral load.

c. A shear-wall with an opening on a rigid base under a uniform load.

d. A shear-wall with an opening on a elastic base under a orm lateral load.

Line Solution and grid analysis techniques were used for all ases though numerical results could be obtained for case 'a' only in the case of Line Solutio

Grid analysis, however. was much more successful and ve lose agreement with experimental results could be obtained in all the cases. Extensive computer programmes were developed for the computation. Necessary tables and graphs have now to be prepared for the stiffness factors and stress concentration ratios for various shapes and sizes of the shear-walls and openings with different boundary conditions. It will take considerable time on the computer but no further thinking is needed for this. These tables and graphs should be so prepared that for any shear-panel the designer should be able to know the equivalent stiffness and expected maximum stress and its location in the panel.

Analysis of Multistorey Buldings

This stage of the problem is more difficult and merits an extensive treatment. The following steps are suggested to obtain the solution. Actually this should form the basis of a completely new theory for the design of tall buildings.

A. The whole buiding is treated as a 3-dimensional structure and all the wind load at a certain floor level is to be taken by all the shear-walls anywhere on that floor in the proper direction. Fig. 1. shows a typical random positioning of the shear-walls in a certain bay of a multistorey building.

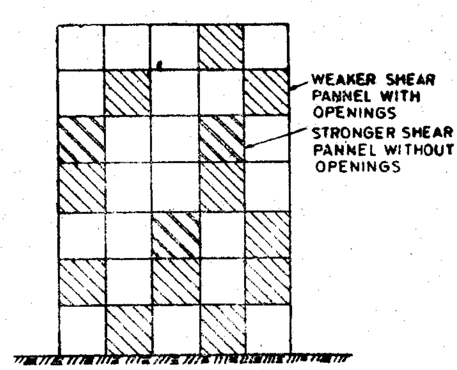


Fig. 1 A Typical Frame with Shearwalls

B. Usually there will be some frames more stiff than others i.e. having more number of, or stiffer shearwalls at a certain level than the others (Fig. 2). Naturally in a continuous structure, such frames should take more wind load compared to the weaker frames, and some transfer of wind load is necessary.

C. This shifting of wind loads from weaker frames to tronger frames is allowed by providing elastic connections between these frames. The transfer takes place through floor slabs acting as horizontal shear-panels. Their stiffness is calculated and substituted as the stiffness of spring connections between the frames (Fig. 3).

D. Analysis of the whole building can be finally done on a large computer, as a series of frames having various stiff panels at different locations (generally represented as an inclined member of equivalent stiffness) and the adjacent frames jioned together by elastic links, (Fig. 4) having the equivalent properties of the floor slabs. The computer time will depend on the number of stories in the building and the number of bays in both directions. For a 9 storey building with 3 and 4 bays in x and y directions, it will be about 1½ hour on Ferranti Pegasus II computer.

Secondary effects like the bending stiffness of roof slabs and cladding should also be considered in the final analysis. This is necessary for accurate prediction of displacements and stresses.

Elastic Properties of Connecting Links

If we consider a symmetrical shear-wall building having similar shear-wall in every storey and bay [3,8] where the overall stiffness of the frames if proportional to the wind load or seismic actions borne by them, it is clear that the individual deflection of each frame will be same and the connecting links shown in figure 4 will remain unstressed. Horizontal shear panels will be under stress only when there is some transfer to load due to unequal deflection of adjacent frames, and the net deflection of a shear panel will be equal to the extension

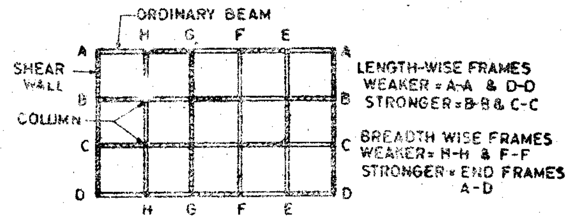


Fig. 2. A Typical Floor Plan Showing Weaker & Stronger Frames in Both Directions.

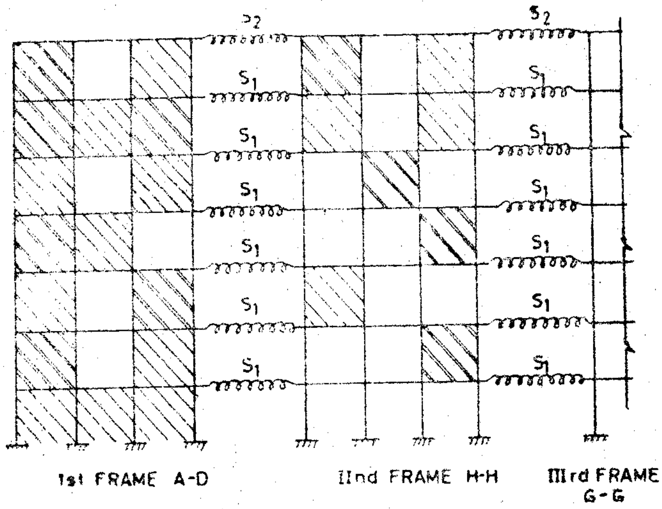


Fig. 3 Connection of Frames by Elastic Links.

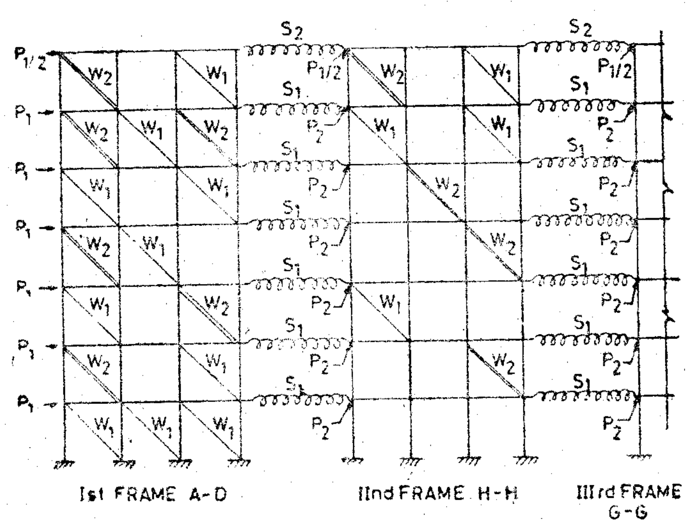


Fig. 4 Reduced Frames with Loading

of the equivalent connecting link. The equivalent area of these links can beound out from this consideration provided the deflection characteristics of the shear panels in question are known.

The moment of inertia of the elastic link could be assumed as zero or it will be hinged at both the ends. This is necessary as horizontal shear panels can not increase the overall stiffness of the building. Their job is only to produce an equitable distribution of horizontal forces.

Experimental work and Results

Experimental investigation for the analysis of single storey shear wall mentioned earlier was done by using 2 dimensional photo-elasticity. Araldite B was used for the models. To facilitate the experimental works quare shear-walls with or without centrally located square holes were used. The agreement between theory (grid analogy) and experiments was very good. As an example, the curves of shear stress for lines "N" and "P" are presented in Fig. 5 and 6. The case is that of a shear-wall with an opening resting on an elastic simply supported beam. These clearly show that the grid analogy technique is quite reliable for complex cases.

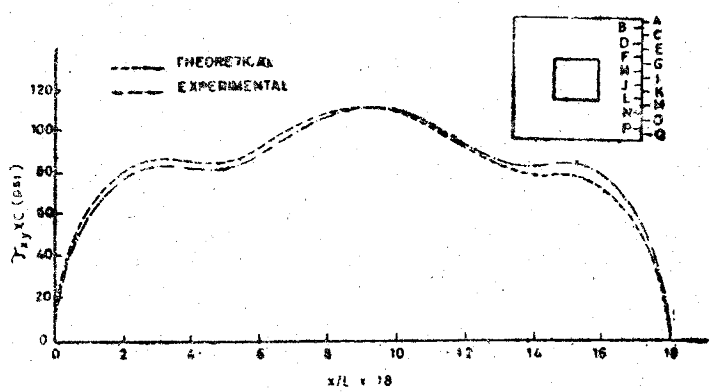


Fig. 5 Shearwall on Elastic Base, Shear Stresses At 'N'

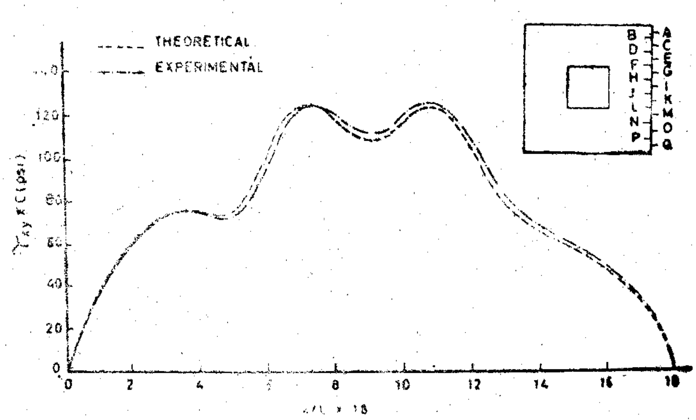


Fig. 6 Sheerwall on Elastic Base, Sheer Stresses At 'P'

Conclusion

The theory discussed in this paper has tremendous possibilities and extensive application in practical problems may be expected when the design curves and tables are made available. Preparation of the design curves is a time consuming process but once they are available, the actual analysis should not take much time on a fast computer. The grid analysis technique is quite suitable and its accuracy is demonstrated by the close agreement between experimental and theoretical results.

References

1. Kazimi, S.M.A., (1966), "The Analysis of Shear-wall Buildings". International Journal of "Building Science" Pergamon Press, London, Paris, New York, Vol. IV.

2. Benjamin, J.R. and Williams, H.A., (1960), Reinforced Concrete Shear-wall Assemblies" Proc. A.S.C.E. Vol. 84. No. ST. 8 Paper 2566.

3. Schulz, M., (1961), "Analysis of reinforeed concrete walls with openings" I.C.J.

4. Ereksson, O., (1961), "Analysis of Wind Bracing Walls in Multi-Storey Housing". Ingenioven-International Edicition. Vol 5 No. 4.

5. Beck, H., (1962), "Contribution to the analysis of coupled shear-walls". Jour. A.C.I. Proc. V. 59, Aug. 1962.

6. Kazimi, S.M.A. and Coull, A., (1965), "The application of Line Solution techniques to the solution of Plane Stress Problems" International Jour. of Mech. Sc. Vol; 6, No. 5 pp. 391–400.

7. Kazimi, S.M.A. and Bari, S.J., (1967), "Further application of Line Solution Techniques—The Plane stress problem with multiply-connected regions". Under publication by I.C.J.

8. Kazimi, S.M A., (1966), "Solution of Plane Stress Problems by Grid analysis". International Jour. of Building Science Pergamon Press, London, Paris, New York.

9. Kazimi, S.M.A., (1967), "Digital Computers and Structural Analysis" Under publication by the 'Cement and Concrete' Journal.

Bulletin of the Indian Society of Earthquake Technology Vol. 4, No. 1, pp. 13–20 January, 1967

EFFECT OF DENSITY AND DYNAMIC LOADS ON SHEAR RESISTANCE OF SANDS

V.V.S. Rao*

Synopsis

At present no rational method is available to calculate the shear strength of sand at any void ratio when the same at a particular void ratio is known from laboratory tests. Similarly the reduction in shear strength due to dynamic loads can not be calculated. In the present paper results of laboratory investigations in this direction are reported. A modified Coulomb's equation is presented which relates the shear strength with static and dynamic normal stresses as well as with angle representing the void ratio.

For a design engineer the variation in the shear strength of sands due to variation in density and due to superposition of dynamic loads on normal static loads is yet an unsolved problem It is of course well known that decreasing denstty as well as increasing dynamic loads reduce the shearing resistance of sands. Lorenz (1) has proposed a rational method of estimating bearing capacity of shallow foundations on the basis of behaviour of soil under shear. But, the application of this method is very much limited as this behaviour directly depends upon void ratio and, as mentioned before, this behaviour is yet not very clear. Although many research engineers have investigated this problem, no useful method is available to predict the shear resistance at any density when the same under a particular density is known.

In a similar manner, we are still in dark about the effect of dynamic loads. It was Hertwing (2, 3, 4) who was the first person to throw some light on this problem. According to his famous resonance theory, the shear resistance under resonance. Thus, he stressed the influence of frequency on the shear resistance. On the other hand, Lorenz (5) is of the view that this reduction might be due to dynamic loads also.

The credit of conducting the pioneer series of dynamic shear tests on sands goes to Mogami and Kubo (6). They fixed a small shear box on a vibrating table and conducted the shear tests so that the vibrations are exerted in a plane perpendicular to the direction of shear force. On the basis of these and some other experiments, they suggested a " liquefaction theory " according to which the soil would behave like a liquid under vibrations. The cause for this effect they gave to be the accelerations of the vibrations. In many of the experiments reported by Mogami, the angle of internal friction of sand is very high, upto 67°. According to him this is due to the friction between the walls of the shear box and sand (7). As one can easily recognize, in the experiments, instead of applying dynamic loads, the sample has been subjected to high inertial forces by fixing it on the vibration table. As such it is the vibration of the table that has been measured aud not of the soil sample itself. Thus one has to be very cautious in applying these results to predict the behaviour of sands subjected to dynamic loads.

Similar experiments have also been conducted by Kutzner 8) who arrives at the same conclusion as Mogami.

On the other hand, Sawtshenko (9) constructed a new type of shear apparatus, wherein the direction of vibrations coincides with that of the shear force. On the basis of his results, Sawtschenko concludes that the reduction in shear resistance depends both upon amplitude as well as on the frequency of vibration. The results seems to be obvious as the vibrations induced coincide with the shearing direction, Hence, it is not possible to arrive at any useful conclusions for design engineers on the basis of the above available results.

*Assistant Professor, Indian Institute of Technology, Delhi.

As such in 1963 a research programme on "the shear strength of dynamically loaded soils" was undertaken by the author in the Institute for Foundation Engineering of the Technical University of Berlin. The main aim of this programme was to conduct intensive dynamic shear tests on sand and investigate the influence of various factors like density, dynamic and static loads on the shear strength of sand. A theoretical investigation assuming sand as a systematic packing of spheres led to the formula for shear resistance as

$$\tau = c + (\sigma_{st} - \sigma_{dyn}) \tan (\varphi + \alpha) \quad (1)$$

where

C = apparent cohesion
σ_{st} = Normal static stress
σ_{dyn} = Normal dynamic stress
φ = Frictional angle between the sand particles,
and α = the angle formed by the slip line at contact points with the direction of the shear stress. In an ideal packing of spheres, α depends upon the void ratio of the packing and varies between 0° and 19° 30′, corresponding to the variation of void ratio from 0.92 to 0.35 respectively. This variation is shown in fig. 1.

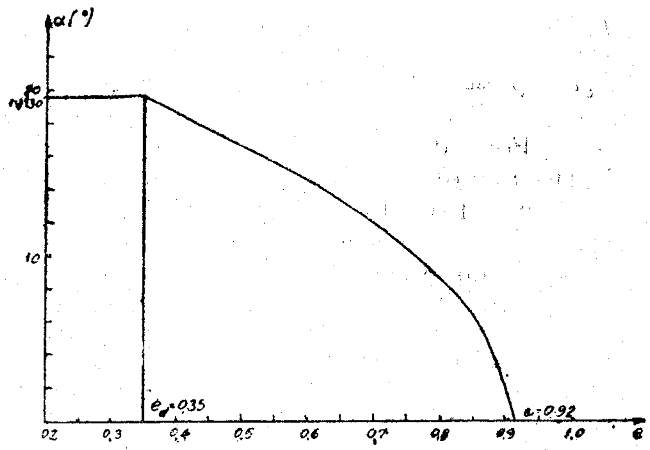


Fig. 1 Relation between the angle 'α' and void ratio 'e'

In deriving this formula, the shear strength of sand is taken to comprise of two resistances; frictional resistance due to interparticle friction, and dilational resistance due to particles "riding" over each other. During the analysis it was found that as the shear takes place, the soil gets compacted in the beginning and when the frictional resistance is fully mobilized, the soil starts expanding, beginning to mobilize dilational resistance. If the vertical deformations during a shear test is measured, a turning point will be observed, when the sample which had all along been consolidating upto that point. starts to expand. This point is called as Point of Reversal (R–Point) (Fig. 2). The shear stress corresponding to this point is the total frictional resistance offered by the sample and the τ in Equation 1. represents this stress. The excess shear stress measured after this point corresponds to the dilational resistance. But, as the dilational resistance depends upon various factors like particle shape and size and direction of shear with respect to particle orientation, it can not be taken into account in designs.

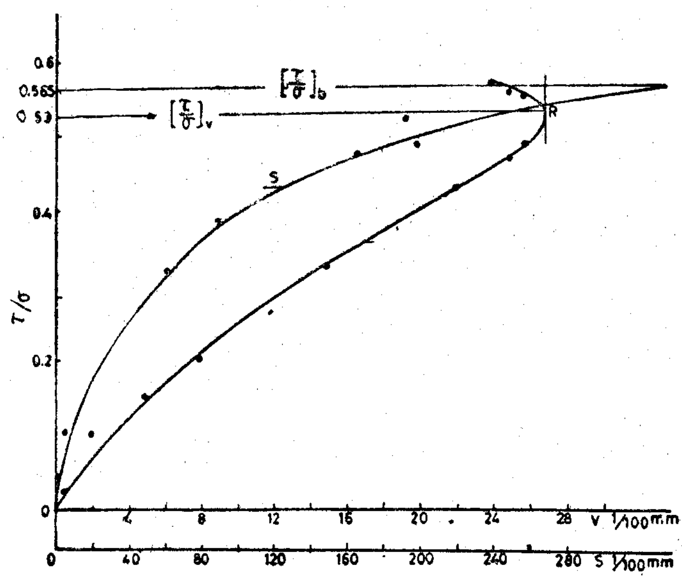


Fig. 2 Typical S and V Diagramme from a static shear test.

In case of purely static loads, Equation 1 reduces to

$$\tau_{st} = c + \sigma_{st} \tan (\varphi + \alpha) \quad (2)$$

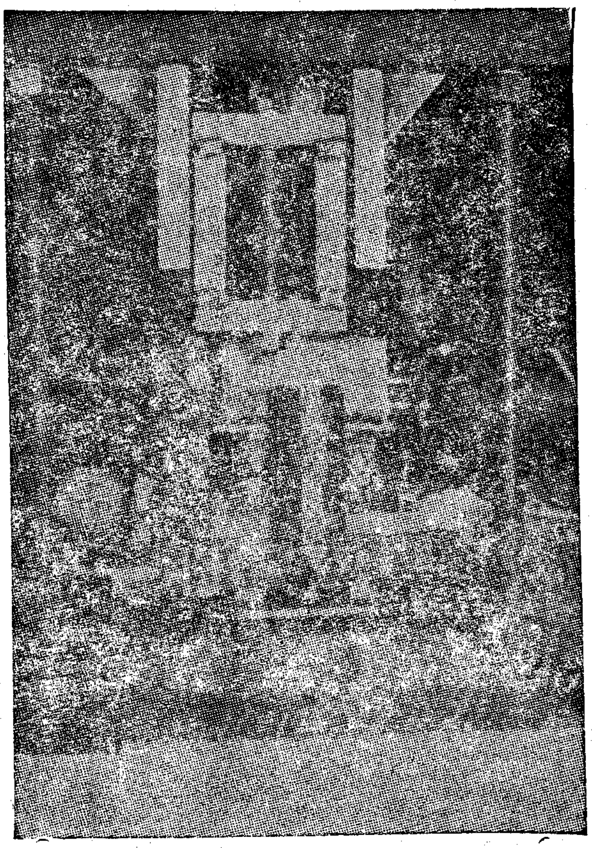


Fig. 3

Fig. 4

A modified constant stress type of Casagrande shear box apparatus was used for conducting the shear tests. In this modified setup, the shear box is fitted with wheels, and rests on a level steel plate fixed over a masonary pillar. The top half of the box is connected to a lever arm on which a wagon loaded with dead weight can be made to move at any required speed with the help of a variable speed motor and chain system. The bottom half is linked to a pendulum with a heavy weight so that the shear load applied at any instant, which is proportional to the movement of the pendulum can be calculated by measuring this movement recorded on a recorder. The vertical load is applied through another lever arm which is so fixed that it can rotate in both vertical as well as in horizontal planes freely obout a fixed point. To apply the dynamic loads, a small mechanical vibration generator was fixed between the top toothed plate of the shear box and the vertical load lever arm. The amplitude of the vibrations induced in the sample was measured with a vibration pick up (Philips-PR 9261) fitted between the top and botton surfaces of the sample as shown in the Fig. (3). With this arrangement frequencies over 100 cps could be attained. The details of the set up are shown in figs. 4, 5 and 6.

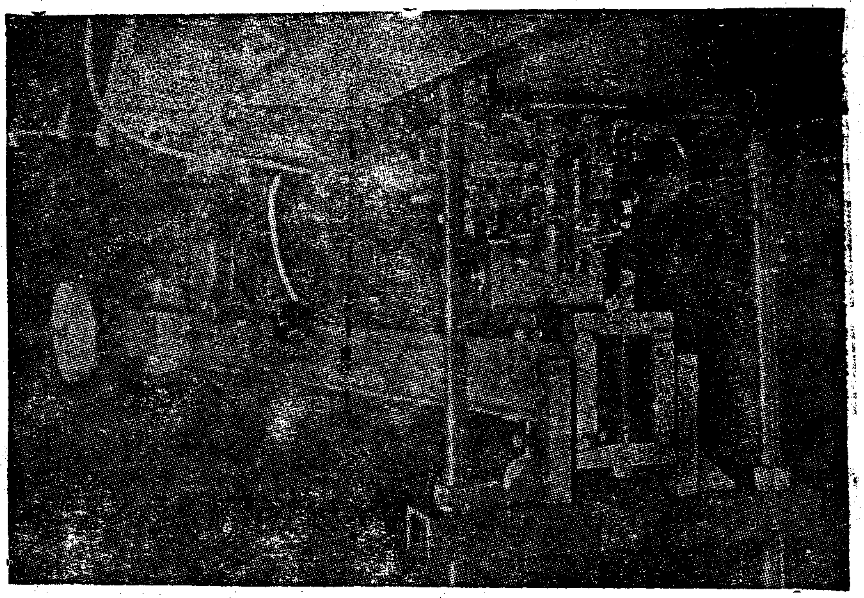


Fig. 6

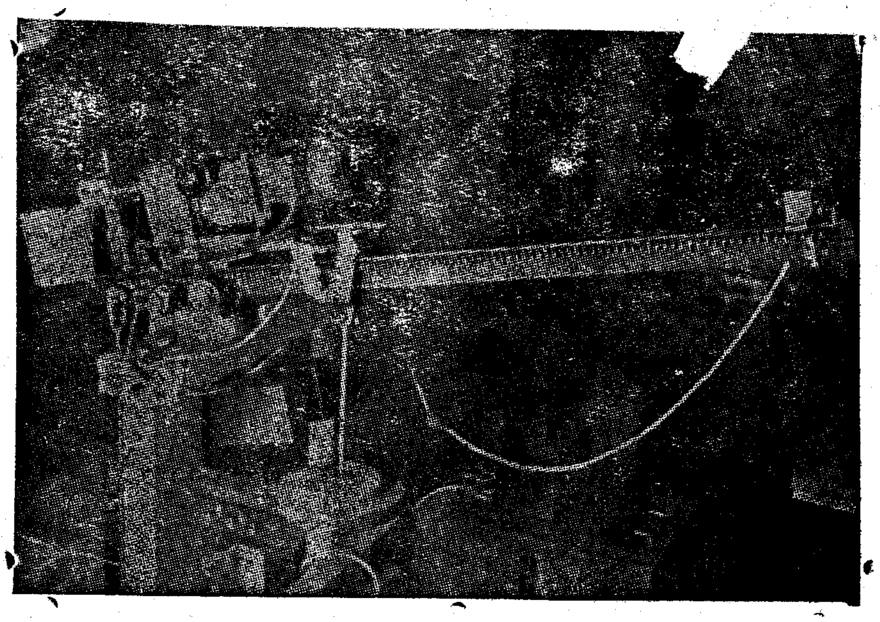


Fig. 7

To determine the void ratio of the sample at the start of the test, the shear box was before hand calibrated for volume against the height - X - as shown in Fig. 7, by casting wax samples in the box and determining its volume later. Thus, not only could the initial void ratio of the sample, but also its variation during the tests could be determined. All tests were conducted on Berlin Sand, whose sieve analysis is reproduced in Fig. 8. To avoid the pore pressure effects, only air dry sand was used for all tests.

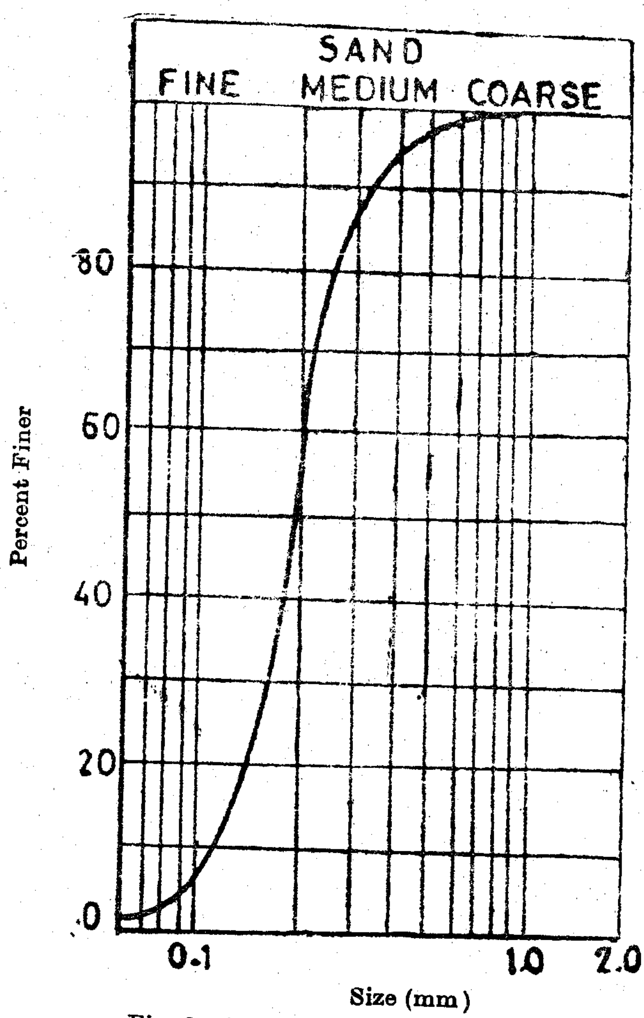


Fig. 8 Grain size distribution of Berlin sand

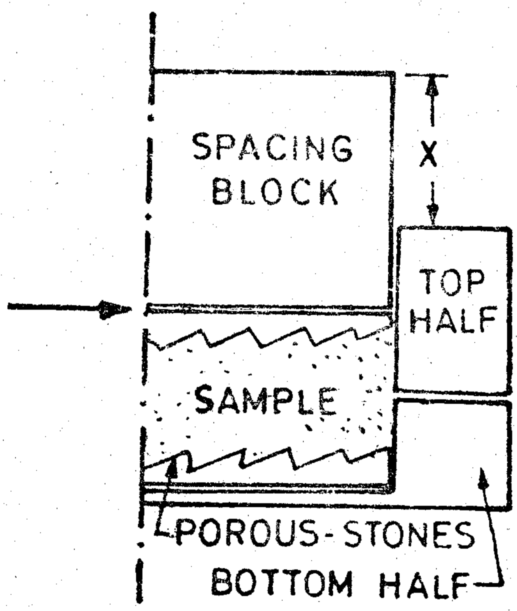


Fig. 7

In the analysis of the results, the τ values corrdsponding to the R-points have been considered. This R-point appeared in all cases and was very conspicuous. A typical curve is shown in fig. (2). From the analysis, it was found that the shear strength equation for this sand is

$$\tau_{st} = 0.1 + \sigma_{st} \tan (10^\circ + \alpha) \quad (3)$$

On the basis of the readings of vertical deformations, trials were made to correlate the change in void ratio with the initial void ratio and the normal loads. But no systematic results could be obtained. Every sample got itself compacted to an arbitrary void ratio. This might have been due to the variation in void ratio within the sample itself.

In order to further verify the validity of the equation (2), the published test results on sand and other cohesionless materials conducted by various investigators have been used. In fig. 9. the angle of interal friction (ϕ) measured in the experiments have been plotted against the void ratio and a smooth curve passing through the points have been drawn. On the same figure, the theoretical variation of α with void ratio (i.e. when $\varphi = 0$ in equation 2) has also been plotted. In can be seen that all the curves run parallel to each other. The distance between any particular curve obtained from the experimental results and the α - curve represents the value of φ in equation 2. This value is independent of void ratio. According to this method of analysis in the experiments of Idell, the angle of friction between glass spheres works out to be 18.5° and that between steel ones 8°. Wittke [15] has experimentally determined the Coefficients of friction of the steel and glass spheres used in the tests and their values are 0.15 and 0.40 respectively, corresponding to the φ values of 8.5° and 21.8°. These values agree well with those obtained by present method of analysis.

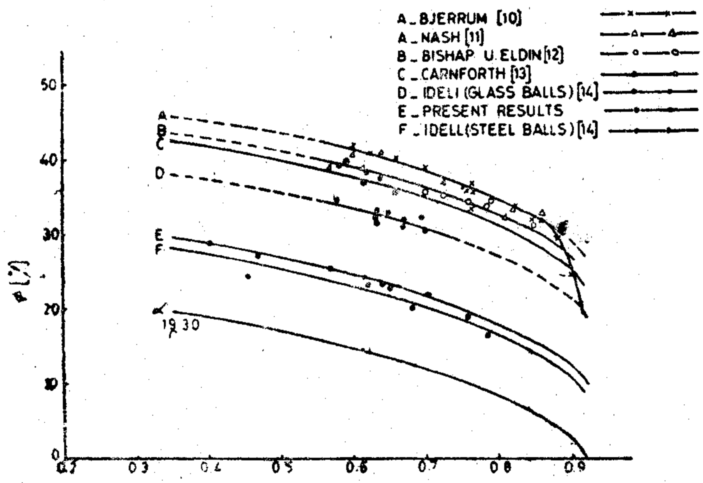


Fig. 9

Thus, the angle in Coulomb's equation has been replaced by a sum of two angles, a frictional angle and an angle depicting the void ratio of the sample. In an ideal case of a packing of uniform spheres, the frictional angle between the spheres can be assumed to a good accuracy. In case of sands however it is very difficult. As such, it is suggested that, at least two well controlled experiments on disturbed samples be conducted in the laboratory so that from known values of σ_{st} and α as well as from the measured value of τ, the two unknow quantities, c and φ can be evaluated to form the shear strength equation for the sand under consideration.

In the case of dynamic shear tests also the shape of the V-Diagrammes had the R-points as in the case of static tests. Only for samples with high void ratios subjected to dynamic loads almost equal to static loads did the sample consolidate continuously upto failure. In such cases the τ value by failure was considered for the analysis.

As in the static case, here also a linear relation between τ/σ vs e, void ratio, was recognized (Fig. 10). The influence of amplitude and acceleration of vibrations on the shear strength was not very regular. This was due to the fact that for every Eccentric mass combination, there existed a particular natural frequency, but this natural frequency had no influence on the shear strength. The influence of the frequency was however more regular. The decrease in shear strength at any particular frequency depends upon the eccentric mass in the vibrator. Fig 11 shows this effect for a particular σ_{st} value.

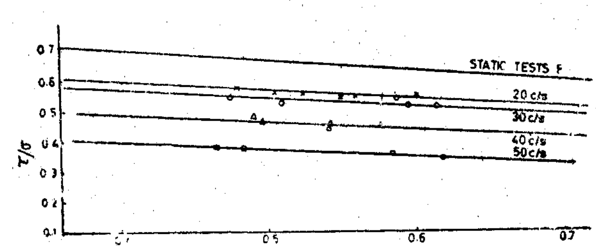


Fig. 10

In Fig. 12 the relation between $(\sigma_{st} - \sigma_{dyn})$ and τ is plotted from all cases of σ_{st} for a particular value of void ratio, e = 0.55. The angle φ for this case is 25.50° same as in static case. Similar curves were also plotted for other values of e and it was found that the values so obtained were the same both in dynamic and static tests. Thus, the shear strength equation under dynamic loads came as

$$\tau_{dyn} = 0.1 + (\sigma_{st} - \sigma_{dyn}) \tan (10^\circ + \alpha) \quad (4)$$

thus confirming the equation (1)

From equations (3) and (4), it follows that

$$\frac{\sigma_{dyn}}{\sigma_{st}} = \frac{\tau_{st} - \tau_{dyn}}{\tau_{st} - 0.1} \quad (5)$$

This results has been plotted in Fig. (13). Hence, in conclusion, it can be said that these theoretical as well as the experimental results have confirmed the views of Lorenz (5) that the value of dynamic loads is the controlling factor in the reduction of shear strength. The shear strength of a sand is related with the density and the dynamic loads as given by equation 1.

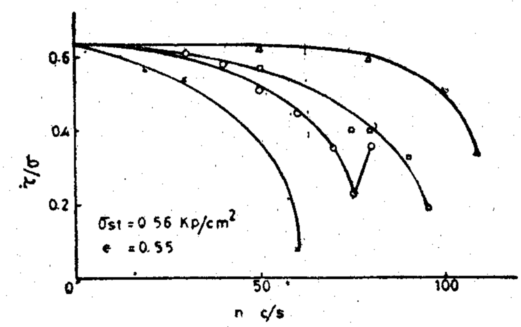


Fig. 11

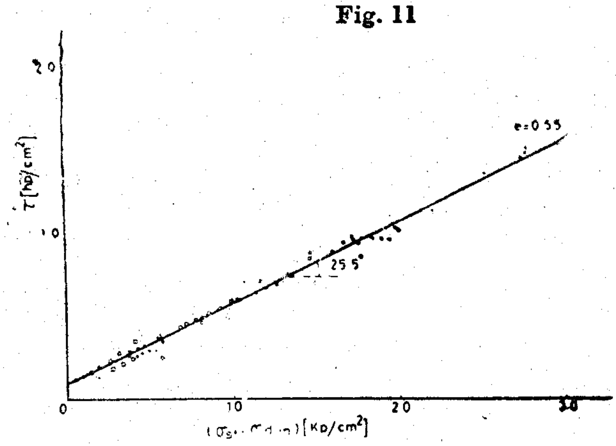


Fig. 12

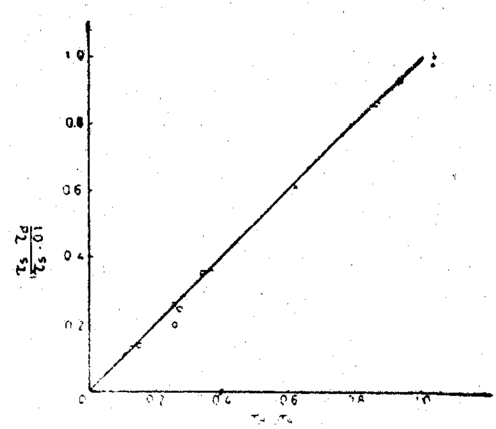


Fig. 13

Acknowledgements

This research programme was carried out during the author's stay in the Grund-bau Institute, Technical University, Berline under the guidance of Prof. Dr. Ing. H. Lorez. The project was financed by the German Counicl of Research. The author is highly thankful to them.

Referencs

1. Lorenz, H. (1962), Verdichtungh und Verängung als Mapstab der Tragfähigkeit rolliger Boden.—Sonderdruck d. Deutschen Gasellschaft fur Erd-und Grundbau eV.
2. Hertwig, A., Fruh, G. und Lorenz, H., (1933), Die Ermittlung der für das Bauwesen wichtigeten Eigen–schaften des Bodens durch erzwungene Schwingunger.—Veröffentl. Degebo, T.H. Berlin, H. 1. Berlin, Springer.
3. Hertwig, A., und Lorenz, H., (1935), Das dynamische Bodenutersuchungsverfahren.—Bauingenieur, (16) Heft 25/26.
4. Lorenz, H., (1960), Grundbau-Dynamick, Springer.

5. Lorenz, H., Üder die Vorgänge im rolligen Baugrund bei Schwingungs-verdichtung.—Forschung sarbeiten aus dem Strassenbauwesen Neue Folge, H. 17, Bielefeld, Kirschbaum Verlag.

6. Mogami, T, and Kubo, K., (1953), The behaviour of sands during vibration.-Pros. 3rd Int. Conf. SMFE., Vol. 1. S. 152.

7. Mogami, T., (1964), (Personal Communication).

8. Kutzner, Christian., (1962), Über die Vogänge in Kornigen Schüttungen bei der Rüttel—verdichtung. Veröffentl. Inst. f. Erd.-u-Grundbau, TH, Karlsruhe Heft 9.

9. Sawtschenko, I.A., (1958), Der EinfluB der Vibration auf die innere Reibung von Sanden. (Überstzung) Dtsch. Gessel. f. Erd–u. Graundcau eV.

10. Bjerrum, L., Krinstage, S. and Kummeneje., The shear strength of a fine sand.—Proc. 5th Int. Conf. SMFE, Vol. 1, p. 29.

11. Nash, K.L., The Shearing resistance of a fine closely granded sand-Proc. 3. Int. Conf. SMFE, Vol. 1, pp. 160–164.

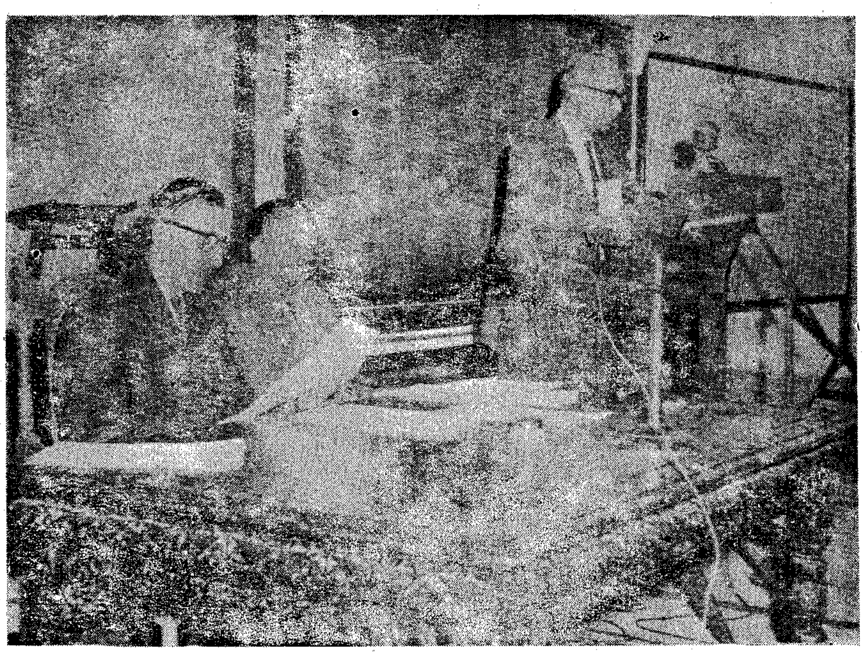
12. Bishop, A.W. and Eldin, AKG, The Effect of stress history on the relatien between Ø and porosity in sand. Proc. 3 Int. Conf. SMFE, Vol. 1 pp. 100–105.

13. Cornforth, D.H., (1964), Some experiments on the influence of strength of sand-Geotechnique 14, pp. 144—168.

14. Idell, K.H., (1960), Die Scherfestigkeit rolliger Erdstoffe.Veoff d. Inst. fur Bodenmechanik und Grundbau, Tech. Hochule, Karlsruhe, H. 2.

15. Wittke, W., (1962), Über die Scherfesting Keit rolliger Erdstoffe—T.H. Karlsruhe, H. 11.

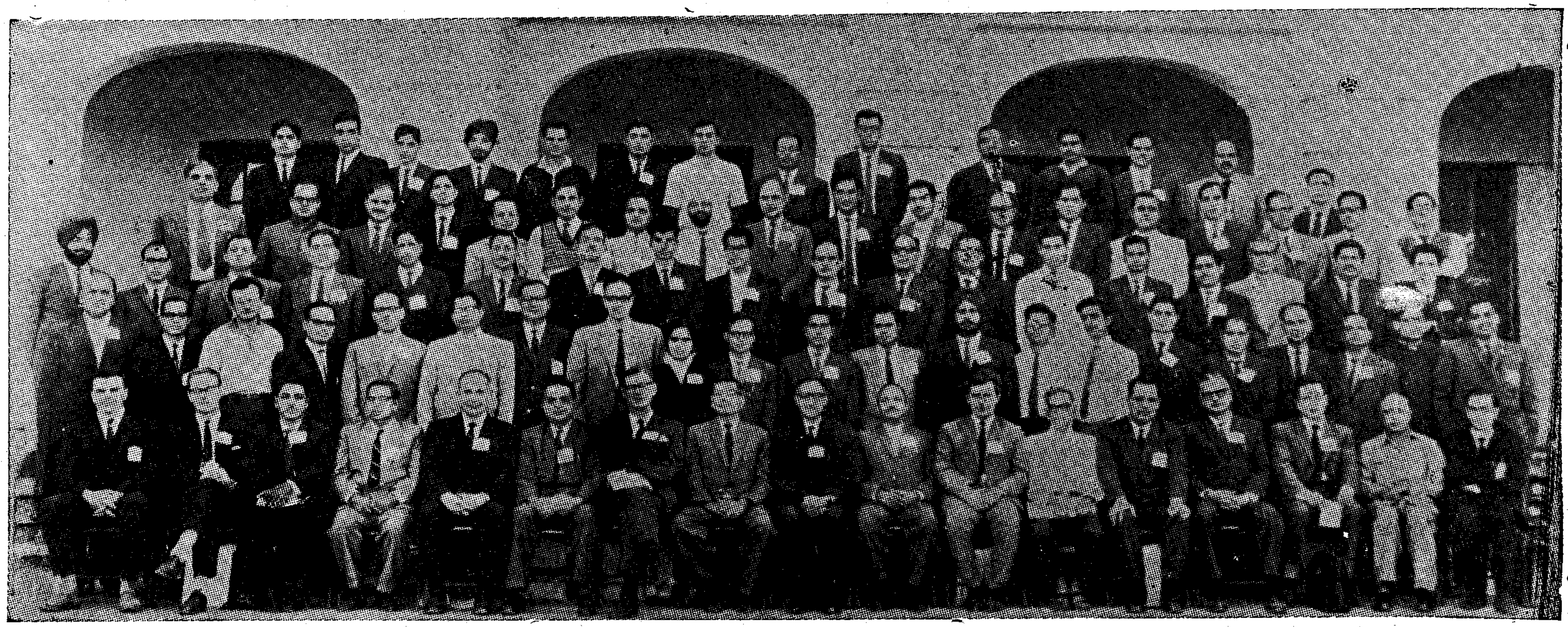
Shri M. R. Chopra, Vice-Chancellor, delivering the welcome and inaugural address at the Third Symposium on Earthquake Engineering on November 4, 1966 at the Senate Hall of the University of Roorkee, Roorkee.



Shri H P. Sinha, delivering the inaugural address at the First General Meeting of the Indian Society of Earthquake Technology on November 5, 1966 at the Senate Hall of the University of Roorkee, Roorkee. Seated in chairs from left to right are Dr. Jai Krishna, President and Dr. A.S. Arya, Secretary of the I.S.E.T.

GROUP PHOTOGRAPH AT THE FIRST GENERAL MEETING OF THE INDIAN SOCIETY OF EARTHQUAKE TECHNOLOGY

November 5, 1966



Sitting L. to R. J.A.Fischer, Esko Arhippainen, J.B. Dessanayake, N.C.Saxena, S.T Algermissen, A.P.Bagchi, A.F. Daldy, C.B. Patel, Jai Krishna (Chairman) A.S. Arya (Secretary), N.N. Yakovlov, R.N. Joshi, A.A. Moinfar, A.N. Tandon, C. Raimondo Cavallo, R.S. Mithal, U. Ventriglia.

Standing 1st Row L. to R. R.C. Jain, P.N. Agrawal, Levchenko, V.V. Subba Rao, K.C. Thomas, A.R. Chandrasekaran, D.V. Reddy, A.H. Gadre, Shyamlata Arora, Anand Prakash, S.B. Sinha, D.K. Chaudhary, Surinder Singh, Bimlesh Kumar, K K. Khurana, Shamsher Prakash, W.S. Zope, B.N. Gupta, Satya Narayan. D.N. Bhargava, S.R. Joshi.

Standing 2nd row L. to R. P.S. Sandhawalia, B.C. Mathur, V.V. Sastry, P.K. Misra, S.N. Tiwari, R.B. Gupta, H.D. Sharma, D.C. Gupta, I.C. Jhamb, G.N. Tandon, R.S. Mathur, R.S. Varshney, Avadh Ram, M.K. Gupta, R.K.S. Chauhan, Chandani, G.C. Nayak, T. Hussain.

Standing 3rd row L. to R. G.S. Rao, M.S. Rao, H.M. Dayal, S.K. Thakkar, S.K. Shome, K.N. Srivastava, B.G. Manohar, Pritam Singh, L.K. Mital, Ravinder Lal, S.M.A. Kazimi, K.R. Venkatakrishna, K.K. Singh, A.K. Biswas, O.P. Bhalla, S.B. Khare, Bharat Singh, B.B. Kumar.

Standing 4th row L. to R. J.K. Jain, P.K. Jain, Y.P. Gupta, S.S. Saini, R.N. Ketkar, S.K. Kanungo, S.N. Bhalla, P.V. Pawar, N. Gosain, S.P. Gupta, O.P. Garg, J.G. Somayajulu, L.S. Srivastava. B.M. Hukku.

Bulletin of the Indian Society of Earthquake Technology. Vol. 4, No. I, January, 1967

FIRST GENERAL MEETING OF THE INDIAN SOCIETY OF EARTHQUAKE TECHNOLOGY

The first general meeting of the Indian Society of Earthquake Technology was held at Roorkee at 6.00 P.M. in the Uuiversity Senate Hall. 34 members of the Society attended the meeting.

The report on the working of the Society, its financial position and statement of accounts was presented by the Secretary and approved.

Revision of the constitution was considered and the various clauses of the amended constitution were approved with necessary modifications.

The Society will now adopt the financial year starting from April Ist, instead of the the calendar year from January Ist, and it was decided that the subscriptions for the year 1967-68 from January Ist, 1967, to March 31st, 1968, be kept as Rs. 18.75 on proportional basis at the rate of Rs. 15.00 per year.

After the business meeting Dr. Jai Krishna, the President of the Society addressed the General Body and the Chief Guest Sri H. P. Sinha, Director General (Road Development) and Additional Secretary, Department of Transport and Shipping (Roads Wing), Ministry of Transport and Shipping, Government of India, New Delhi delivered the inauguaral address.

The general meeting was followed by a contributory dinner in the E.S. Mess.

ADDRESS BY THE PRESIDENT

Dr. Jai Krishna*

I am very thankfull to the members of the Indian Society of Earthquake Technology to have elected me as their President for the second time. I am very conscious of the responsibility that this office brings on to me particularly at this stage of development of the Society. One of the greatest difficulties that we face is that the terms "Earthquake Technology" or even "Earthquake Engineering" are not generally understood. The other day I was attending a meeting of the National Institute of Sciences in Delhi and two very distinguished scientists asked me what the term "Earthquake Technology" meant and they said that "we understand by 'Technology' some thing connected with 'Production' and if this Society aims to encourage production of earthquakes you can hardly expect any support from us". I said "Will Earthquake Engineering be understood better" the reply was that "Engineering earthquakes is no better than producing them". Similarly when this University admitted the first batch of the post graduate students to the course on Earthquake Engineering, the students wanted me to explain to them the full significance of the term "Earthquake Engineering" before they would take admission. This has been the situation for all these three years, but now I feel gratified that the term, the work and the objectives of the field of study of earthquake technology and consequently the aims of this Society are very much better

* Professor and Director, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee.

understood. We got full quota of 10 students for post graduate work this year and the membership of the Society has increased over 200. We are now receiving more and more appreciation from the members regarding the quality of its publications. Demand for them in India and abroad has considerably improved.

The Society offers a unique opportunity of providing a common ground for structural engineers, soil and foundation engineers, electronic engineers, mechanical engineers, geologists and seismologists to get together and collaborate in facing the problem that arises from the most devasting, unpredictable and indeterminate of all nature's forces that confront man on this earth. I should have added zoologists also to this list because it has sometimes been observed that animals and birds seem to feel the coming of an earthquake much earlier than it actually arrives They might thus discover a metbod of sounding an alarm bell for earthquakes. They are quite welcome if they would like to join us. No other field seems to offer such an opportunitry for collaboration between scientists and engineers trained in such different disciplines. The importance of such a Society, therefore, cannot be over-emphasised.

There are two main facets of the problem that engages the attention of scientists and engineers at present. One deals with the prediction of earthquakes. It would be a very laudable objective to be able to predict them particularly because it is impossible to prevent them. The actual work involved in this problem however, presents great difficulties and huge expenditure. The state of prediction at present is that we could locate the areas where earthquakes could be expected to occur in future, but we cannot pin-point the epicentres or predict the time of occurrence of earthquakes or their size. In this state of knowledge, half-baked prediction can lead to very serious psychological and socio-economic problems. We should look forward to the day when some one can predict earthquakes so accurately that life and property can be saved, but till this knowledge gets perfected it would be dangerous to forecast them. There is now a school of thought that consider the expenditure on research in prediction to be a waste since the ultimate problem is that of engineering which has to be solved in any case whether we can predict or not. That is a point of view. Both programmes are important but if we have to choose between them due to shortage of resources, the engineering programme obviously takes a precedence.

The engineering research programme, as undertaken in India and abroad, consists of developing methods of analysis, devices of measuring vibrations, methods of strengthening engineering structures etc. These problems have to be tackled irrespective of our knowledge regarding the time of earthquake occurrence.

Gentlemen, it is well-known to you that India is one of the most seismic countries of the world. Huge areas extending from Assam in the east to Kashmir in the north and Gujrat in the west have been affected by earthquakes from time to time. Towards the location of the epicentres the India Meteorological Department maintains certain number of seismological stations and they are increasing the number of such stations gradually. A helping hand has also been given in this direction by a few river valley project authorities with results that several new observatories have come up in Punjab, U.P., Bihar and it is hoped that more and more such stations will be established in all regions where future projects are likely to be located. Another set of stations with the object of recording response of structures to strong ground motion during earthquake has been established by the School of Research and Training in Earthquake Engineering. 28 such stations in the seismic areas have already been established and a similar number is in the process of installation in the next few months. The objective of establishing these stations is to record the maximum force that the structures of different kind will be subjected to during earthquakes which cause strong motion in the region where the station is located. They automatically take into account the geology of the region and the foundation conditions in the area. The Earthquake School has taken up the design and manufacture of more elaborate accelerographs to develop this programme. A similar programme has been undertaken very intensively in USA and Japan, but due to non-availability of foreign exchange we had to design and develop our own instruments for the purpose. It has naturully delayed progress in this direction. Other countries also are now taking up this work. These instruments, in course of time will offer a lot of information which will be of direct use to design engineers.

The Earthquake School has also undertaken a programme of engineering studies including strengthening of brick buildings water towers, dams, arches, shells and different kinds of foundations against earthquake forces. These are producing results which have been utilised increasingly by various organisations in the country. An attempt is also being made to find corelations applicable to this country between the size of earthquakes and the energy transmitted at a particular location on account of it. This will help engineers in assessing more accurately the ground motion which an earthquake of certain size will cause in specific areas. Similar other problems have been taken up and the results will be published in the bulletins of this Society and other important journals dealing with such problems published in various parts of the world in course of time.

The Society is functioning as a clearing house for the technical material of proper quality offerred to it for publication. I hope the Society is steadily building itself up and serving the purpose for which the delegates of the Second Symposium proposed its formation. If, in course of time, the knowledge disseminated by the publications of this Society enables the saving of some lives and property during future earthquakes, a great purpose will have been served.

I thank you very much once again for asking me to serve the Society in the capacity as its President and I take the opportunity to invite all delegates to the Symposium who are not members of the Society so far to join us and develop this technical work at a high academic and professional level.

ADDRESS OF THE CHIEF GUEST

Sri H. P. Sinha*

I am greatful to the Indian Society of Earthquake Technology for giving me this opportunity to be with you. The Vice-Chancellor and your President, Dr. Jai Krishna, have been good enough to ask me to inaugurate this session.

Although earthquakes are perhaps one of the earliest natural destructive phenomenon known to mankind, it is strange that the science for the study of earthquake has not received adequate attention so far. Fortunately the parts of the word seriously affected by earthquakes are not very extensive, but still the earthquakes can be extremely destructive and also take a large toll of life if an area is visited by a severe type. India is not free from the ravages of earthquakes and more than one instance can be found in the history of States like Assam, Bihar and Baluchistan (when it was a part of India), that very heavy loss both of life and property occurred due to severe earthquakes. Your society is, therefore, playing a very important role by furthering the science dealing with earthquakes. Your success will mean saving property and many precious lives.

*Director General (Road Development) and Additional Secretary, Department of Transport & Shipping (Roads Wing), Ministry of Transport and Aviation, Govt. of India, New Delhi.

Your society was formed in 1962 and I am told that you are meeting for the first time after the General Meeting of 1962. Your Session is coinciding with the session of the Symposium on earthquake engineering at which various developments in this branch of engineering and technology are being discussed and I am sure the delibrations will lead to further enhancemect of knowledge of this science. One of the results of your activity is reflected in the formulation of the "Indian Standard Recommendations for Earthquake Resistant Design of Structurers" issued in November 1962. This standard provides valuable information for designing structures in the regions prone to earthquakes in this couutry. It has revised the map of India showing the seismic zones and has also indicated six zones instead of three as orginally provided. The horizontal seismic co-efficient can now be applied to a locality with a little more presision and is bound to lead to considerable economy and safety in structures.

As the science of earthquake engineering is still in infancy, your society has a large field open to it for observation, study and research. So far the provisions in the ISI code are generally based on the meagre visual informations available from the various destructive effect that have been noticed as a results of some of the earthquakes. The scientific analysis for these occurances have not yet been possible because of the lack of complete data. It is hoped that with the suggestions and guidance given by your Society the record of further observations will be collected and compiled, not only more extensively but also more accurately, so that it would be possible to corelate them with the various mathematical analysis that are evolved while studing the action of earthquakes. No doubt the final results can be obtained only after the detailed observations have been carried out for a prolonged period but still let us hope that it will be possible to make a move towards finding some interim solutions even with the results of observations of a few years.

In the absence of detailed informatin in regard to the manner in which damages have occured in this country due to earthqaukes, it is necessary for us to study the researches carried out in other conntries which experience similar earthquakes and to draw conclusions for applications in our country as far as possible. Japan and the United States of America are among the few countries who have given considerable thought to this problem and have arrived at conclusions which can be useful to our country also. Different structures are bound to behave differently under the stresses caused by earthquake and, therefore the observations made for any types of structure cannot automatically be extended to other types of structures. Hence it will be necessary to carry out more extensive and individualistic researches for covering all the fields. As an example, the general impression of the study of damage caused by earthquake on bridges, is that the damage is more in the foundations and sub-structure than the super-structure, In the super-structure the damage is more generally caused by the movement of the girders as a whole (due to which it topples down) than by the failure of individual members of the girders which rest on moveable bearings, and is therefore of utmost importance in the case of a bridge structure. A proper design for preventing this movement can be easily evolved and standardised. The cost of such device will be insignificant when compared to the cost of the bridge. A considerable amount of safety can, therefore, be built in the bridge structure with a small amount of additional expenditure.

Now that the science of prestressed concrete has developed considerably, it is possible to make concrete structures slender enough to be flexible. This will specially apply to bridge piers, A slender and flexible structure has more chance of standing the stress like that of an earthquake, than a massive rigid piece. If it can be mathematically proved that this impression is really correct, perhaps a preference for prestressed concrete structures of this type can be usually given for the areas which have heavy earthquake shocks.

The soil conditions also play a very important role in the effect of the shock from earthquake. A soft soil or a fill is generally fatal. A precaution in this respect, therefore, should normally be taken invariably and that should not cost much. A deep foundation is known to have a damping effect against the oscilation of the pier of a bridge and is, therefore, preferable to shallow foundations. When a deep foundation is made by sinking wells, it is usefull to provide intermediate diaphragms in the well to strengthen the steining. It may also be desirable that in earthquake areas, the wells may be of cement concrete, lightly reinforced, instead of brick or stone masonary.

It is obviously not possible to provide for the effect of the worst earthquake because when the ground literally slips under your feet, nothing can prevent damage to a structure. But fortunately such heavy earthquakes are few and far between and affect only a small area. But it is the less violent earthquakes which, being larger in number, perhaps cause more destructions and it is these earthquakes which can be taken care of by judicious use of knowledge after study of earthquake technology. While damege to some structures like a dam or a bridge may or may not cause a very big disaster to a population, the collapse of houses cause much loss of life. Here the damage generally occurs to the house which are inadequately built structurally or are in a poor state of repair. One of the fairly effective construction technology for house building in earthquake areas was to make them in timber. These structures being light and also being able to stand tention better than masonary, were generally less affected by earthquakes. With the dearth of timber such constructions are now getting replaced by heavier structure in masonary and concrete. The necessity for providing safety in house structures has thus become all the more urgent. Fortunately the larger structures of reinforced concrete are generally safe; but still most of the houses are of brick or stone masonary where it should be obligatory to make them safe by providing devices like reinforced concrete bands and verticals in the structures. The average man is ignorant of the imperative necessity of such safety measures and he has to be guided by rules and regulations of the town authorities. Your advice as to in which regions such construction should be compulsory may be very useful to the town authorities in framing their regulations. It may also be a good idea for the society to prepare a model regulation giving at the same time reasons for the recommendations made, so that the authorities concerned can fully appreciate the necessity of exercising control over the construction of building structures in such regions.

You may therefore like to organise the activities of the society in such a manner that groups of experts in several aspects of the study have opportunity to sit together or exchange views by correspondence in the periods in between your annual meetings and thus bring out concrete proposals for ratification by the General Body at the annual sessions. For this objective perhaps an arrangement of working in Sub-committees will be very appropriate. Each Sub-Committee will presents its report on the work done and progress made during the year. The Society will in due course be in a position to formulate some kind of codes or standards as would be expected form a learned body like yours.

May I again thank you for according this opportunity to me to be with you. I am confident that your activities will help the country in gaining greater safety against earthquake and thus make the living in such areas free from anxiety.

REPORT ON THE WORKING OF THE SOCIETY AS ON OCTOBER, 1966

The decision to establish the Indian Society of Earthquake Technology was taken at the time of the Second Symposium on Earthquake Engineering held at this University in 1962. The Society actually came into existance in January 1964 by which time all the formalities of registration etc. were over. Since then this is the first general meeting of the Society. Therefore I take the opportunity to place before you how the Society has been progressing during the last 2 years and 10 months of its existence.

Membership

The total number of Individual Members at present is 168 from India and 19 from abroad and that of the Institution Members is 21. The State and country-wise break-up of the present Membership is given in the Appendix. The yearwise progress of enrolment is given in the following table.

Membership	Enrolled during the year			
	1964	1965	1966 upto 31-10-66	Total
Individual Membership	133	33	23	189
			Withdrawn	-2
				187
Institution Membership	15	4	2	21

Membership drive

A circular letter was sent on July 15, 1966 to all Engineering Institutions in the country for attracting new Institution and Individual Members. There has been good response and 10 new Individual Members have been enrolled during the last two months.

Publications of Bulletin

The Society has so far published two Bulletins in the year 1964; two Bulletins in the year 1965 and two Bulletins in the year 1966. According to a decision taken by the Executive Committee in the end of 1965, there aught to be three Bulletins in the present year. It was however decided in a subsequent meeting that in lieu of the third issue of the Bulletin in the current year. the members of the Society may be supplied the proceedings of the Third Symposium on Earthquake Engineering to be held on November 4th to 6th, 1966 at a concessional price of Rs. 25/- each against the full price of Rs. 45/-. A formal notification to this effect was inserted in the Society Bulletin Vol. III, No. 2.

The features covered in the Bulletin at present are the news of the Society, technical papers, seismological notes and abstracts of papers published in other journals in the general field of earthquake engineering. Your suggestions to include any other special features in the Bulletin are invited.

Funds

The position of funds of the Society has not been comfortable. Some times it has led to some what delayed publications of the Bulletin. Unfortunately the subscriptions of many members have remained in arrears. The position of payment of subscriptions as on 31.10.66 is shown below Efforts have been made to have the payments upto date as a result of which we have now a balance of Rs. 2486.99 as compared with Rs. 1028·98 as on 31.12.65. This places the Society in better position for publishing its Bulletin regularly and with increased frequency.

In order to strengthen the financial position of the Society, a request has been made to Government of India, Ministry of Education, New Delhi. for giving a grant-in-aid to the Society. It is hoped that some grants will be made available to the Society by the end of the current financial year. It is also proposed to request the State Governments of Earthquake Affected Zones for grant-in-aid for furthering the objectives of the Society.

Position of Payments of Membership Fee as on 31 October, 1966

Members	*Present strength*	*Not paid for 1965*	*Not paid for 1966*
Institution Members	21	3	5
Individual Members	187	49	77

Constitution

For improvement in the working of the Society, some changes were felt necessary in the Constitution. The more immediate was the election procedure which used to be by election at the time of general meeting. This has now been changed to postal ballot by taking the consent of members by correspondonce. Some other amendments are proposed so as to activate the Society, the most important among them being the holding of an annual general meeting in the month of April every year. The financial year of the Society is proposed to be changed to April 1 to March 31 so that the elections could be held in March and the Annual General meeting be held in April where in the new Executive may take over charge. At this meeting it is proposed that that the papers published in the Bulletines in the previous year may be discussed.

It is proposed to request the Railway Board to extend the Travel Concession to the members attending meetings of the Society on the same lines as it is extended to other societies. I would also recuest your approval to payment of single first class train or bus fares to the members of the executive for attending the meetings from the Society funds wherever necessary and if funds permit.

Elections

Elections were held in the month of Nov./Dec.' 65 for the new Executive Committee by postal ballot and the present Committee took over charge in March 1966. If the proposed amendments to the Contitution are approved, the new Electians will be due in March 1967.

Acknowledgements

In the end I take this opportunity for expressieg the appreciation on behalf of the all the members of the Society for the spade work done by the first Executive Committee to bring the Society into existance and start it going in the right direction for fulfilling its aims.

A. S. Arya
Secretary

APPENDIX

State-wise break up of the Members of the Society

State	Individual Members	Institution Members	Forgein Members	
Assam	4	1	Canada	1
Andhra Pradesh	6	1	Greece	1
Bengal	8	3	Japan	2
Delhi	21	8	Mexico	2
Gujrat	1	—	Nepal	1
Himachal Pradesh	2	1	U. K.	4
Jammu & Kashmir	1	—	U. S. A.	8
Kerala	1	—		
Maharashtra	16	3		19
Madras	3	—		
Mysore	6	—		
Madhya Pradesh	7	—		
Orrisa	3	—		
Punjab	9	—		
Rajasthan	5	1		
Field Employees (from Military)	1	—		
Uttar Pradesh	74	3		
	168	21		

Annual Statement of Accounts of 'ISET' for the Period from Ist January 1965 to 31st December 1965

Receipts		*Total Rs.*	*Expenditure*	*Total Rs.*
Opening balance				
a) Cash at Bank	Rs. 688.48		1. Printing	1622.05
b) Cash in hand	Rs. 246.86	935.34	2. Postage	258.55
1. Membership fee	——————	2673.85	3. Remuneration	265 00
2. Sale of Bulletin		123.90	4. Bank Commission	20.00
3. Advertisement		Nil	5. Stationery	481.51
			6. Closing balance	1082 98
	Total Rs.	3730.09	Total Rs.	3730.09

Balance Sheet of 'ISET' as on 31st December, 1965

Liabilities			*Assets*		
Remuneration payable	Rs.	20.00	Stock of Bulletin in hand	Rs.	4282.50
Capital (excess of Assets given below)	Rs.	5345.48	Cash at Bank	Rs.	1067.98
			Outstanding cheque	Rs.	15.00
			Cash in hand		Nil
Total	Rs.	5355.48	Total	Rs.	5365.48

Details of Bulletine in Stock

1.	Bull. Vol. I, No. 2	207 Nos.	Rs.	1552.50
2.	Bull. Vol. II, No. 1	189 Nos.	Rs.	1417.50
3.	Bull. Vol. II, No. 2	175 Nos.	Rs.	1312.50
			Rs	4212.50

Bulletin of the Indian Society of Earthquake Technology. Vol. 4, No. 1, January, 1967

CONSTITUTION OF THE INDIAN SOCIETY OF EARTHQUAKE TECHNOLOGY*

Article 1—Name of the Society

1.1 The name of the Society shall be "Indian Society of Earthquake Technology" and shall be referred to as the 'Society' hereafter in these articles.

1.2 The headquarters of the Society will be at Roorkee.

Article 2—AIM and OBJECTS

2.1 The aim of the Society shall be

(a) to provide necessay forum for seismologists, geophysicists, geologists and engineers to come together and exchange ideas on the problems of earthquake technology.

(b) to disseminate the knowledge in the field of earthquake technology dealing with seismological, geological and engineering aspect.

2.2 The Society shall maintain close liason with the International Society for Earthquake Engineering and other national and International institutes working with allied objectives.

Article 3—Membership

3 1 The membership of the Society is open to all individuals, institutions connected with or interested in any aspect of Earthquake Technology-Seismology, Geology or Engineering.

3.2 The Society shall have following categories of membership.

(i) Institution Members

(i i) Members.

3.3 *Institution Members*—The Institution Membership is open to all Institutions (Universities, Colleges, Government Departments, Design or Construction Firms and the like) interested in earthquake technology.

3.4 *Members*—The Membership of the Society is open to all individuals associated with or interested in Earthquake Technology. In addition to this, he must have the following qualifications :

(a) Any recognised Engineering Degree or its equivalent such as corporate membership.

or

(b) A Master' Degree in any branch of Science or Technology or its equivalent.

Article 4—Subscriptions

4.1 The financial year of the Society will be from April 1st to March 31st and the annual subscription will be payable in advance on the 1st April, each year.

4.2 The rates of subscription for different categories of Membership are given in the Bye-laws to the constitution.

Article 5—Forfeiture of Membership

5.1 A member will forfeit his membership if his or her subscription for any year is not paid till 31st March of the year to which it relates and his name is liable to be removed from the list of members after serving notice to the defaulting member to this effect.

5.2 Readmission will be made only after payment of all the arrears upto date.

*As passed by the General Body on November 5, 1966.

Article 6—Application for Membership

6.1 Application for membership shall be supported by at least two members of the Society and shall be made to the Secretary of the Society.

6.2 The Executive Commitee, as defined in Article 7, will take all decision regarding enrolement of new members.

Article 7—Executive Committee

7.1 The management of the Society shall be in the hands of the Executive Committee which shall consist of 12 persons including office bearers of which atleast 2 shall be from amongst the representatives of the Institution Members.

7.2 The Executive Committee will be elected by the members of the Society from amongst the members of the Society. The election will take place annually in the month of March by postal ballot.

7.3 The Executive Committee shall consist of the following :—

1.	President	1
2.	Vice-President	1
3.	Secretary and Treasurer	1
4.	Editor	1
5.	Elected members	8

7.4 The office bearers will hold office for one year but they will be eligible for re-election. No office bearer will hold the same office for more than three consecutive years.

7.5 The Executive Committee shall have all powers in the direction, management and promotion of objectives of the Society subject to any limitation imposed on its functioning by the Genrai Body.

Article 8—Meetings of the Society

8.1 The Executive Committee shall arrange a General Body meeting at least once a year.

8.2 At the General Meeting there will be paper discussions, and other important activities in fulfilment of the obligations of the Society.

8.3 The quorum for General Meetings and Executive Committee meetings shall be 25% of their membership.

8.4 At the time of Annual General Meeting, the Secretary will present the annual budget, statement of accounts and reports duly approved by the Executive Committee for the approval of the General Body.

Article 9—Finance and Funds

9.1 The Society shall raise funds for pursuing the objectives of the society through :—

(a) Subscriptions from the members

(b) Grant from Government and other organisations

(c) Any other source approved by the Executive Committee.

9.2 The Society shall maintain a current account with the State Bank of India, Roorkee University Branch, Roorkee into which subscriptions etc., collected shall be credited and the account will be operated by the Secretary of the Society.

Article 10—Privileges

10.1 Priviliges of the various categories of the members shall be regulated as per the provision in the bye-laws to the Constitution.

Article 11—Duties of the Secretary

11.1 The Secretary shall be responsible for the maintenance of the office of the society including all routine correspondence and operation of society funds in accordance with the directives from Executive Committee.

11.2 The Secretary will be responsible for the preparation, maintenance and circulation of all minutes of meetings.

11.3 The Secretary will be responsible for all society publications.

BY-LAWS OF THE INDIAN SOCIETY OF EARTHQUAKE TECHNOLOGY "ISET"

1. Subscriptions

1.1 The subscriptions for the different categories of members will be as under :—

(a) Institution Members—Rs. 100.00 per year (foreign US. $ 20.00 or equivalent)

(b) Members—Rs, 15.00 per year (foreign US $ 3.00 per year or equivalent)

1.2 The annual subscriptions of Members may be compounded for life as set out in the table in the Appendix.

1.3 The subscriptions will be collected on yearly basis from April to March and will be payable in advance on April 1st for the financial year.

2. Privileges

2.1 All members are entitled to participate in the meetings of the Society and receive publications of the Society free of charge as under :—

(a) Institution Members 3 copies

(b) Members 1 copy

3. Annual Report

3.1 Annual report for any year will cover all the activities of the Society during the previous year. This report should contain the audited statement of the accounts of the previous financial year and Secretary's report regarding the activities of the Society.

APPENDIX

Table of Life Compounding Fee

Age next birthday	Rs.	US $ or equivalent from abroad	Age next birthday	Rs.	US $ or equivalent from abroad
25 or less	200.00	40.00	38	168.00	33.60
26	198.00	39.60	39	164.00	32.80
27	196.00	39.20	40	160.00	32.00
28	194.00	38.80	41	155.00	31.00
29	192.00	38.40	42	150.00	30.00
30	190.00	38.00	43	145.00	29.00
31	188.09	37.60	44	140.00	28.00
32	186.00	37.20	45	135.00	27.00
33	184.00	36.80	46	128.00	25.60
34	182.00	36.40	47	121.00	24.20
35	180.00	36.00	48	114.00	22.80
36	176.00	35.20	49	107.00	21 40
37	172.00	34.40	50 or over	100.00	20.00

Bulletin of the Indian Society of Earthquake Technology Vol. 4, No. 1, pp. 35–45 January, 1967

SEISMOLOGICAL NOTES

(India Meteorological Department, New Delhi)

Earthquakes in and near about India during January—September, 1966

Date	Origin time (G M.T.) h. m. s.			Epicentre Lat. (°N)	Long. (°E)	Region	Approx. depth (Kms.)	Magnitude	Remarks
1	2	3	4	5	6	7	8	9	10
Jan. 4	07	47 (CCS)	00.0	11.8	95.0	Andaman-Islands	33	5.1 (CGS)	—
Jan. 5	17	21 (SHL)	20.0	13.0	96.0	Andaman-Islands	—	—	Recorded at many Indian Observatories
	17	21 (CGS)	28.4	13.2	95.5	Andaman-islands	37	5.3 (CGS)	—
Jan. 5	20	45 (CGS)	54.6	38.2	69.1	Tadzhik SSR	33	4.9 (CGS)	—
Jan. 11	09	12 (CGS)	59.3	34.0	72.0	W. Pakistan	40	5.4 (CGS)	Recorded at a few Indian Observatories felt at Bilaspur
Jan. 16	07	07 (CGS)	56·9	9.2	93.8	Nicobar-Islands	33	5.2 (CGS)	Recorded at a few Indian Observatories.
Jan. 19	01	45 (CGS)	26.1	3.4	97.3	Northern Sumatra	33	4.8 (CGS)	—
Jan. 24	02	15 (CGS)	27.7	32.7	67.6	Afghanistan	33	5.2 (CGS)	—
Jan. 24	07	22 (SHL)	50	30.0	68.0	W. Pakistan	—	6 0 (NDI)	Recorded at many Indian Observatories.
	07	23 (CGS)	07.6	29.9	69.7	W. Pakistan	12	5.8 (CGS)	—
Jan. 24	15	32	48.1	29.9	69.8	W. Pakistan	4	5.3 (CGS)	Recorded at many Indian Observatories.
Jan. 25	15	02 (NDI)	11.0	2?0 kms. away from Delhi		—	—	3.6 (NDI)	Felt at Bilaspur.
Jan. 28	08	52 (SHL)	02	39.0	73.0	Hindukush	—	—	Recorded at many Indian Observatories.
	(8	52 (CGS)	02.2	39.3	73.1	Hindukush	20	5.4 (CGS)	—
Jan. 31	02	35 (CGS)	05.8	27.9	99.6	Yunnan Province, China	33	5.6 (CGS)	Recorded at a few Indian Observatories.
Feb. 2	09	20 (CGS)	07.5	33.9	73.0	W. Pakistan	26	5.3 (CGS)	Recorded at many Indian Observatories. Felt at Rawalpindi and Havelian.

1	2 3	4	5	6	7	9	9	10
Feb. 3	12 46 (NDI)	26.2	40 kms. N·W. Delhi		—	—	—	Felt at Sonepat.
Feb. 7	04 26 (SHL)	00.0	30.0	68.0	W. Pakistan	—	—	Recorded at many Indian Observatories.
	04 26 (CGS)	13.9	29.8	69.7	W. Pakistan	33	6.0 (CGS)	12 dead, extensive damage at Barkhan and nearby villages. Felt at Bhawalpur, Fort Manro and Lahore.
Feb. 7	05 21 (CGS)	44.6	30.0	69.9	W. Pakistan	10	5.4 (CGS)	Felt.
Feb. 7	05 30 (CGS)	19.2	30.0	69.6	W. Pakistan	48	5.3 (CGS)	Felt.
Feb. 7	08 38 (CGS)	11.3	30.0	69.9	W. Pakistan	15	4.8 (CGS)	Felt.
Feb. 7	23 06 (SHL)	30.0	31.0	69.0	W. Pakistan	—	—	Recorded at many Indian Observatories.
	23 06 (CGS)	34.5	30.2	69.8	W. Pakistan	10	5.8 (CGS)	Felt in Loralai District, Bhawalpur. Fort Manro and Multan.
Feb. 8	00 11 (CGS)	32.2	30.1	70.0	W. Pakistan	34	—	—
Feb. 9	08 22 (SHL)	20	29.0	70.0	W. Pakistan	—	5.4 (NDI)	Recorded at many Indian Observatories.
	08 22 (CGS)	17.9	29.8	69.8	W. Pakistan	29	5.2 (CGS)	Felt in Quetta, Multan and Bhawalpur areas.
Feb. 9	22 26 (CGS)	06.6	30.0	69.9	W. Pakistan	6	4.6 (CGS)	—
Feb. 12	08 04 (CGS)	57.8	39.1	71.6	Tadzhik SSR	70	4.7 (CGS)	—
Feb. 12	I6 34 (CGS)	11.3	36.6	71.5	Afghanistan-USSR Border	188	4.9 (CGS)	—
Feb. 13	02 17 (NDI)	52.0	30 kms. S-W of Delhi		—	—	4.8 (NDI)	Felt Locally.
Feb. 13	02 59	28.4	30 kms. S-W of Delhi		—	—	—	Felt Locally.
Feb. 13	19 09 (CGS)	47.4	29.8	69.7	W. Pakistan	33	5.1 (CGS)	Felt at Barkhan.
Feb. 14	05 41 (CGS)	06.5	29.3	69.5	W. Pakistan	·44	4.8 (CGS)	Recorded at a few Indian Observatories.
Feb. 16	09 44 (GGS)	21.5	29.9	69.7	W. Pakistan	34	4.6 (CGS)	—
Feb. 17	09 28 (NDI)	38.4	10 kms. away from Delhi		—	—	—	Felt Locally.

1	2	3	4	5	6	7	8	9	10
Feb. 17	18	26 (CGS)	17.7	29.9	69.8	W. Pakistan	22	4.4 (CGS)	Recorded at a few Indian Observatories.
Feb. 19	09	43 (CGS)	01.3	37.4	70.3	Afghanistan USSR Border	33	4.8 (CGS)	—
Feb. 19	12	50 (CGS)	42.1	35.3	70.9	Hindukush	59	5.1 (CGS	Recorded at many Indian Observatories. Felt at Peshawar.
Feb. 24	00	16 (SHL)	36.0	26.0	91.0	Goalpara, Assam	—	—	Recorded at many Indian Observatories.
	00	16 (CGS)	40.5	26.4	91.5	E. India	47	5.1 (CGS)	Felt at Shillong.
Feb. 27	01	23 (NDI)	29.9	10 kms N-W of Delhi		—	—	—	Felt at Sonepat.
Feb. 28	20	05 (CSG)	05.7	35.8	71.3	W. Pakistan	153	4 4 (CGS)	—
March 1	04	59 (CGS)	53	36.5	69.0	Hindukush	78	4 6 (CGS)	—
March 2	04	02 (CGS)	46.5	36.1	70.6	Hindukush	162	4.5 (CGS)	—
March 4	06	01 (CGS)	05	30.0	70.0	W. Pakistan	33	4.4 (CGS)	Recorded at a few Indian Observatories.
March 6	02	10 (CGS)	56.8	31.6	80.5	Tibet	35	5.4 (CGS)	Recorded at a few Indian Observatories.
March 6	02	15 (CGS)	56.7	31.6	80.5	Tibet	44	6.1 (CGS)	Recorded at many Indian Observatories.
March 7	22	36 (CGS)	03	29.2	98.6	Tibet	17	5.2 (CGS)	Recorded at a few Indian Observatories.
March 9	15	06 (CGS)	28	34.8	80.2	Tibet	33	4.5 (CGS)	—
March 11	04	20 (CGS)	21	30.1	69.9	W. Pakistan	32	4 4 (CGS)	—
March 14	04	42 (CGS)	50	32.4	97.4	Tibet	33	4 9 (CGS)	—
March 15	09	14 (CGS)	29.3	29.9	69.7	W. Pakistan	32	4.7 (CGS)	—
March 16	00	08 (CGS)	19	33.1	75.9	E Kashmir	57	5.2 (CGS)	Recorded at a few Indian Observatories.
March 16	17	40 (CGS)	30	29.7	69.8	W. Pakistan	33	4.7 (CGS)	Recorded at a few Indian Observatories.
March 17	05	44 (CGS)	50.5	31.5	82.8	Tibet	33	5.0 (CGS)	Recorded at a few Indian Observatories.
March 18	10	44 (CGS)	09	29.8	69.9	W. Pakistan	33	4.4 (CGS)	Recorded at a few Indian Observatories.

1	2	3	4	5	6	7	8	9	10
March 26	18	51 (CGS)	10	29.9	69.7	W. Pakistan	36	4.0 (CGS)	Recorded at a few Indian Observatories.
March 30	21	14 (NDI)	00.5	40 kms. N-W of Delhi		--	—	—	Felt at Sonepat.
March 31	23	37 (SHL)	55.0	37.0	71.0	Hindukush	—	6.0 (NDI)	Recorded at many Indian Observatories.
	23	38 (CGS)	00.5	36.4	70.8	Hindukush	200	5.6 (CGS)	—
April 4	02	17 (CGS)	18.1	11.8	92.6	Andaman Islands	33	5.0 (CGS)	Recorded at a few Indian Observatories.
April 4	02	51 (CGS)	39.0	12.0	92.7	Andaman Islands	33	5.0 (CGS)	Recorded at a few Indian Observatories. Felt at Porr Blair.
April 4	06	42 (CGS)	00.0	11.5	94.0	Andaman Islands	—	—	Recorded at many Indian Observatories. Felt at Port Blair.
	09	42 (CGS)	33.9	12.1	92.7	Andaman Islands	33	5.0 (CGS)	—
April 5	00	07 (CGS)	34.6	12.2	92.7	Andaman Islands	33	4.7 (CGS)	Recorded at a few Indian Observatories.
April 6	01	51 (CGS)	51.8	35.0	73.0	West Pakistan	38	5.1 (CGS)	Recorded at a few Indian Observatories. Felt in Kashmir.
April 8	22	15 (CGS)	04.4	36.3	70.6	Hindu Kush	224	4.9 (CGS)	—
April 11	16	42 (SHL)	50 0	39.2	71.0	Tadzik SSR	—	—	Recorded at a few Indian Observatories.
	16	42 (CGS)	53.5	38.8	70.6	Afghanistan USSR border	29	4.8 (CGS)	—
April 13	03	00 (CGS)	19.0	36 5	70 8	Hindukush	171	4.4 (CGS)	—
April 14	16	33 (CGS)	28.8	04.8	96.2	Northern Sumatra	30 —	4.9 (CGS)	Recorded at a few Indian Observatories.
April 14	21	06 (SHL)	05 0	40.0	72.0	Kirgiz	—	5.3 (NDI)	Recorded at a few Indian Observatories.
	21	06 (CGS)	17.4	38.9	70.6	Afghanistan USSR border	33	5.2 (CGS)	—
April 18	19	29 (CGS)	40.5	34.5	69.8	Afghanistan	52 (CGS)	—	Recorded at a few Indian Observatories.
April 21	09	31 (CGS)	14.4	4.9	95.1	Northern Sumatra	66	4.3 (CGS)	—
April 22	10	06 (CGS)	00.7	36.6	71.1	Hindukush	226	4.5 (CGS)	Recorded at a few Indian Observatories.

1	2	3	4	5	6	7	8	9	10
April 22	20	04 (NDI)	21.4	20 Kms S-W of Delhi.			—	3.0 (NDI)	Felt locally.
April 23	04	17 (CGS)	25.5	23.0	90.4	Eastern India	33	5.1 (CGS)	—
April 25	18	11 (SHL)	50.0	30.5	69.8	West Pakistan	—	4.9 (NDI)	Recorded at a few Indian Observatories.
	18	11 (CGS)	54.7	30.1	69.9	West Pakistan	29	4.4 (CGS)	—
April 25	23	22 (CGS)	52.6	41.2	69.3	Kirgiz SSR	33	5.1 (CGS)	10 killed, 100 injured, and major property damage at Tashkent.
April 26	10	45 (CGS)	32.8	24.8	96.5	Burma	33	4.8 (CGS)	Recorded at a few Indian Observatories.
April 27	10	58 (CGS)	29.5	0.1	98.7	Northern Sumatra	33	4·9 (CGS)	—
April 30	13	41 (CGS)	09.1	41.0	72.1	Kirgiz SSR	19	5.1 (CGS)	Recorded at a few Indian Observatories.
May 7	18	28 (CGS	18.6	34.6	70.7	Afghanistan	17	4.4 (CGS)	Recorded at a few Indian Observatories.
May 11	01	55 (SHL)	00.0	34.2	69.9	Near Kabul	—	5.8 (NDI)	Recorded at a few Indian Odservatories.
	01	53 (CGS)	56.7	34.6	69.9	Afghanistan	27	5.1 (CGS)	Felt at Kabul.
May 12	11	42 (CGS)	46.2	40.2	78.4	S. Sin Kiang Provice, China	33	4.7 (CGS)	Recorded at a few Indian Observatories.
May 13	23	12 (CGS)	34.4	29.8	69.9	West Pakistan	27	4.0 (CGS)	Recorded at a few Indian Observatories.
May 15	02	13 (CGS)	02.8	39.6	74.1	S. Sinkiang Province, China	51	4.9 (CGS)	—
May 15	17	16 (CGS)	16.2	36.6	71.0	Hindu Kush	213	4.8 (CGS)	Recorded at a few Indian Observatories.
May 19	05	58 (CGS)	40.3	39.8	78.1	S. Sinkiang Province, China	33	5.1 (CGS)	Recorded at a few Indian Observatories.
May 20	20	19 (CGS)	01.9	40.6	73.4	Kirgiz SSR.	33	4.7 (CGS)	—
May 23	07	48 (CGS)	26.0	24.1	95.6	Burma	33	4.8 (CGS)	—
May 24	04	35 (CGS)	24.0	30.1	70.0	West Pakistan	20	3.9 (CGS)	—
May 27	14	35 (CGS)	05.3	27.4	96.5	Burma-India Border	51	4.8 (CGS)	—
May 27	22	13 (SHL)	45	25.0	66.0	N. Arabian-Sea	—	6.4 (NDI)	Recorded at many Indian Observatories.
	22	14 (CGS)	14.1	24.4	68.7	India-West Pakistan border	5	5.1 (CGS)	—
May 29	15	03 (CGS)	50.3	24.0	95.2	Burma	68	—	—

1		2	3	4	5	6	7	8	9	10
May	30	12	51 (CGS)	57.9	36.0	68.8	Hindukush	220	4.6 (CGS)	— —
June	4	05	11 (SHL)	57.0	36.5	71.6	Hindukush	—	6.1 (NDI)	Recorded at many Indian Observatories.
		05	11 (CGS)	54.2	36.3	70.8	Hindukush	207	5.7 (CGS)	—
June	5	08	29 (CGS)	23.0	24.6	93.2	Burma-India Border	33	4.1 (CGS)	—
June	6	07	46 (SHL)	08.0	36.0	69.0	Hindukush	—	6.1 (NDI)	Recorded at most of Indian Observatories. Felt in Delhi, Gulmarg, Srinagar, Chandigarh, Amritsar and Jammu. In Srinagar the museum building was damaged and 100 houses developed deep cracks. The ceiling of the Central hall of the museum collapsed and almost all the walls of the bnilding had suffered cracks. Show cases containing manuscripts were damaged when the ceiling came down. The Civil Secretariat in Srinagar also suffered minor cracks, in the quake. The chimney of the High Court building fell down. Most of telephone connections went out of commission.
June	7	07	46 (CGS)	16.2	36.3	71.2	Afghanistan USSR Border	225	6-3 (CGS)	Felt at Faizabad and Dushambe.
June	9	00	12 (CGS)	12.1	7.6	94.1	Nicobar-Islands	55	5.3 (GCS)	Recorded at a few Indian Observatories.
June	11	06	08 (CGS)	49.1	35.7	72.2	West Pakistan	104	4.9 (CGS)	Recorded at a few Indian Observatories.
June	11	22	29 (CGS)	37.3	36.6	70.7	Hiudukush	192	4.5 (CGS)	—
June	12	20	56 (NDI)	07.1	40 kms. N-W of Delhi		—	—	2 9 (NDI)	Felt at Sonepat.
June	20	13	42 (CGS)	57	28.7	76.9	N. India	33	4.7 (CGS)	Recorded at a few Indian Observatories. Felt in Delhi and Sonepat.
June	21	14	21 (NDI)	33.4	40 kms. N-W of Delhi		—	—	2.6	Felt at Sonepat.

1		2	3	4	5	6	7	8	9	10
June	21	19	46 (CGS)	45.2	36.5	70.9	Hindukush	180	4.7 (CGS)	Recorded at a few Indian Observatories.
June	23	17	42 (CGS)	05	36.3	71.3	Afghanistan USSR border	111	4 4 (CGS)	Recorded at a few Indian Observatories.
June	24	07	05 (CGS)	20	36.6	71.5	Afghanistan USSR border	194	—	—
June	25	04	54 (NDI)	22.3	40 kms. N-W of Delhi		—	—	—	Felt at Sonepat.
June	25	12	05 (CGS)	04.7	30.5	82.3	Tibet	35	4.8 (CGS)	Recorded at a few Indian Observatories.
June	26	10	56 (CGS)	09	26.3	93.0	E. India	48	5.0 (CGS)	Recorded at a few Indian Observatories. Felt at Shillong.
June	27	10	41 (SHL)	05	29.5	81.0	W. Nepal	—	6.3 (NDI)	Recorded at most of the Indian Observatories. Felt at Delhi, Ambala, Kanpur, Barelly, Moradabad, Nainital, Jullunder, Simla, Ashkote, Lucknow, Chandigarh, Rohtak, Panpat, Pathankot, Amritsari, Agra, Rishikesh, Muzaffar-Nagar, Khurja, Gurgaon, Kathmandu, Dehradun, Sitapur, Bahraich and Pokhara. Some buildings in Dehli, Ambala and Nainital, developed cracks. In the Ambala city the roof of a double storey building, which housed the main post office, collapsed. In Moradabad several old houses collapssed. In Bajhang and Darchula district of Nepal about 300 houses were destroyed or damaged, leaving nearly 10,000 people homeless. Between 50 and 100 people might have died.
		10	41 (CGS)	08.6	29.7	80.9	Nepal India	37	6.1 (CGS)	80 killed, many injured, major damage, at Baitadi, Darchula and Chainpur, Nepal.
June	27	10	47 (CGS)	43	29.5	80.9	Nepal India border	28	5.3 (CGS)	—

1	2	3	4	5	6	7	8	9	10
June 27	10	49	50.0 (CGS)	29.8	80.7	Nepal-India border	33	5 8 (CGS)	—
June 27	10	59	18.1 (GGS)	29.7	81.0	Nepal-India border	40	6.0 (CGS)	Recorded at a few Indian Observatories.
June 27	11	21	43 (CGS)	29.7	80.8	Nepal-India border	33	5.4 (CGS)	Recorded at a few Indian Observatories.
June 27	13	55	51.9 (CGS)	29.6	80.8	Nepal-India border	35	5.4 (CGS)	Recorded at a few Indian Observatories.
June 28	15	43	38 (SHL)	29.5	81.1	West Nepal	—	4·9 (NDI)	Recorded at a few Indian Observatories.
	15	43	37 (CGS)	29.4	81.1	Nepal	33	5.4 (CGS)	—
June 29	00	42	08.6 (CGS)	29.8	81.0	Nepal-India	12	4.9 (CGS)	Recorded at a few Indian Observatories.
July 3	12	47	08.0 (CGS)	36.2	71.1	Afghanistan USSR border	229	4.6 (CGS)	Recorded at a few Indian Observatories.
July 4	08	45	50.1 (CGS)	36.6	70.9	Hindukush	120	4.6 (CGS)	—
July 5	10	01	21.5 (CGS)	27.5	92.4	India-China border	77	4.8 (CGS)	Recorded at a few Indian Observatories.
July 6	11	57	23.5 (CGS)	39.0	71.2	Afghanistan USSR border	19	4.8 (CGS)	—
July 7	11	24	01.1 (NDI)	22 Kms. N-W of Delhi			—	2.4 (NDI)	Felt at Sonepat.
July 7	19	00	26.6 (CGS)	36.8	71.3	Afghanistan USSR border	33	4.2 (CGS)	—
July 12	10	01	54.3 (CGS)	9.6	92.9	Nicobar Islands	33	4.5 (CGS)	—
July 12	14	04	28.1 (CGS)	36.7	71.4	Afghanistan USSR border	143	—	Recorded at a few Indian Observatories.
July 16	19	43	27.4 (CGS)	40.7	74.2	Kirgiz Sinkiang border	33	4.8 (CGS)	Recorded at a few Indian Observatories.
July 19	03	28	52.6 (CGS)	36.2	71.4	Afghanistan USSR border	138	4.5 (CGS)	Recorded at a few Indian Observatories.
July 23	17	44	58.5 (CGS)	36.5	70.8	Hindu Kush	210	4.6 (CGS)	Recorded at a few Indian Observatories.
July 24	05	07	39.5 (CGS)	30.1	69 9	West Pakistan	9	4 3 (CGS)	—
July 26	15	15	31.7 (CGS)	36.8	71.6	Afghanistan USSR border	114	5.0 (CGS)	Recorded at a few Indian Observatories.
Aug. 1	19	09	50.0 (NDI)	30.0	69.0	West Pakistan	—	5 9 (NDI)	Recorded at most of the Indian Observatories.
	19	09	55.1 (CGS)	29.9	68.8	West Pakistan	33	5.8 (CGS)	—

1	2 3	4	5	6	7	8	9	10
Aug. 1	20 30 (SHL)	52.0	30.0	68.0	West Pakistan	—	6.0 (NDI)	Recorded at most of the Indian Observatories.
	20 30 (CGS)	57.0	29.9	68.6	West Pakistan	33	5.7 (CGS)	—
Aug. 1	21 02 (SHL)	50.0	30.5	68.0	West Pakistan	—	—	Recorded at most of the Indian Observatories.
	21 02 (CGS)	59.6	30.0	68.7	West Pakistan	33	6.2 (CGS)	2 killed, 15 injured. About 45 villages destroyed. Felt in Quetta'
Aug. 1	21 35 (CGS)	41	29.9	69.0	West Pakistan	29	4.8 (CGS)	—
Aug. 1	22 30 (CGS)	54.8	30.0	68.9	West Pakistan	33	5.2 (CGS)	—
Aug. 2	05 41 (CGS)	37.4	30.0	68.8	West Pakistan	32	5.3 (CGS)	—
Aug. 2	09 18 (CGS)	57.6	29.9	69.2	West Pakistan	21	5.1 (CGS)	Recorded at a few Indian Observatories.
Aug. 3	22 13 (CGS)	20.1	37.2	71.2	Afghanistan USSR Border	33	5.0 (CGS)	Recorded at a few Indian Observatories.
Aug. 4	22 29 (CGS)	28	29.8	68.6	W. Pakistan	54	4.9 (CGS)	—
Aug. 5	01 03 (SHL)	00.0	32.5	80.0	Western Tibet	—	5.9 (NDI)	Recorded at most of the Indian Observatories.
	01 03 (CGS)	04.4	32.6	79.6	Kashmir Tibet border	55	5.3 (CGS)	—
Aug. 10	22 05 (CGS)	35.0	38.4	69.6	Tadzhik SSR	4	5.5 (CGS)	Recorded at a few Indian Observatories.
Aug. 14	05 08 (CGS)	30.8	38.3	73.7	Tadzhik Sinkiang border	102	5.1 (CGS)	—
Aug. 15	02 15 (SHL)	35.0	28.0	79.0	Central U.P.	100	5.3 (NDI)	Recorded at most of the Indian Observatories. Felt extensively in Uttar Pradesh and adjoining areas of Punjab. In Moradabad thirty persons were injured, fifteen of them seriously in house collapses following the earthquake. A few houses, some well built damaged. Some minor damage occured also at Bariely and Meerut.

1	2	3	4	5	6	7	8	9	10
	02	15 (CGS)	33.8	28.7	78.9	N. India	50	5.8 (CGS)	—
Aug. 15	10	20 (CGS)	42.2	3.8	64.0	Carlsberg Ridge	37	5.6 (CGS)	Recorded at a few Indian Observatories.
Aug. 15	12	10 (CGS)	49	29.8	68.6	W. Pakistan	31	4·7 (CGS)	—
Aug. 16	02	16 (SHL)	15.0	37.5	70.0	Hindu Kush	200	6.4 (NDI)	Recorded at many Indian Observatories. Felt at Srinagar.
	02	16 (CGS)	19.7	36.4	70.8	Hindu Kush	199	5.7 (CGS)	Felt at Peshawar.
Aug. 17	19	16 (NDI)	51.6	41 Kms. N-W of Delhi			—	—	Felt at Sonepat.
Aug. 22	21	28 (CGS)	29	24.9	61.8	Near Coast of W. Pakistan	33	4.7 (CGS)	—
Aug. 24	02	47 (CGS)	01	37.2	73.2	Tadzhik SSR	72	4.6 (CGS)	—
Aug. 24	06	51 (CGS)	15.8	29.9	68.6	W. Pakistan	33	5.1 (CGS)	Recorded at many Indian Observatories.
Aug. 28	10	43 (SHL)	00.0	36.0	70.0	Hindu Kush	—	5.9 (NDI)	Recorded at many Indian Observatories.
	10	43 (CGS)	01.0	36.3	70.9	Hindu Kush	173	4.9 (CGS)	—
Aug. 31	01	19 (CGS)	01	36.5	71.4	Afghanistan USSR border	80	5.0 (CGS)	Recorded at a few Indian Observatories.
Sep. 2	06	16 (NDI)	50.8	40 kms. N-W of Delhi		—	—	—	Felt at Sonepat.
Sep. 4	04	37 (CGS)	04.5	12.2	93.1	Andaman-Islands	33	5.4 (CGS)	Recorded at many Indian Observatories.
Sep. 8	12	18 (CGS)	14.8	36.4	70.2	Hindukush	223	4.9 (CGS)	Recorded at a few Indian Observatories.
Sep. 11	15	55 (CGS)	20	27.0	95.8	Burma-India border	37	5.0 (CGS)	—
Sep. 18	12	19 (CGS)	38.4	22.6	101.9	Burma-China border	33	4.5 (CGS)	—
Sep. 19	05	03 (CGS)	46.6	23.9	97.6	Burma-China border	15	5.1 (CGS)	Recorded at a few Indian Observatories.
Sep. 20	23	37 (CGS)	21.8	24.1	97.6	Burma-China bordet	28	5.2 (CGS)	Recorded at a few Indian Observatories.
Sep. 22	04	51 (CGS)	12	37.3	72.1	Tadzhik-SSR	135	4.6 (CGS)	—
Sep. 25	01	23 (CGS)	34.2	24.6	94.8	Burma-India border	74	4.2 (CGS)	Recorded at a few Indian Observatories. Felt at Shillong.

1	2	3	4	5	6	7	8	9	10
Sep. 26	05	10	55.0 (SHL)	27.6	92.8	Balipara frontier Track, Nefa	—	5.6 (NDI)	Recorded at a few Indian Observatories. Felt at Shillong. Gauhati, Dibrugarh. Tezpur, North Lakhimpur and Jorhat.
	05	10	58.1 (CGS)	27.5	92.6	India-China border	33	5.6 (CGS)	—
Sep. 26	06	03	48 (CGS)	27.6	92.7	India-China border	33	4.2 (CGS)	—
Sep. 27	19	22	46 (CGS)	14.8	93.7	Andaman-Islands	69	4.5 (CGS)	Recorded at a few Indian Observatories.
Sep. 28	14	00	20.0 (NDI)	28.0	100.0	S-E China	—	6.5 (NDI)	Recorded at most of the Indian Observatories.
	14	00	22.9 (CGS)	26.4	100.1	Yunnan Province China	33	6.2 (CGS)	—
Sep. 28	16	56	01 (CGS)	27.3	100.0	Yunnan Province China	33	4.6 (CGS)	—
Sep. 28	23	50	01 (CGS)	27.4	100.1	Yunnan Province China	33	4.9 (CGS)	—

Bulletin of the Indian Society of Earthquake Technology. Vol. 4, No. 1, January, 1967

THIRD SYMPOSIUM ON EARTHQUAKE ENGINEERING UNIVERSITY OF ROORKEE, ROORKEE (November 4-6, 1966)

The Third Symposium on Earthquake Engineering was held at the University Senate Hall from November 4 to 6, 1966. Mr. M. R. Choprl, Vice-Chancellor, Inaugurated the Symposium and presided over the Technical Session on 'Design of Dams and Appurtenent Works in Earthquake Zones'. Prof. S. R. Mehra, Director, Central Road Research Institute, New Delhi presided over the technical session on 'Soil and Foundation Behaviour during Earthquakes'; Mr. H.P. Sinha, Director General (Road Development) and Additional Secretary, Ministry of Transports, Government of India and Mr. N C. Saxena, Chief Project Engineer, Yamuna Valley Project ,Dehradun presided over the technical sessions of 'Structural Response and Design of Structures for Earthquake and Blast Forces'. Mr. C.B. Patel, Director, National Buildings Organisation, New Delhi presided over the session on 'Housing in Seismic Zones and Damage During Recent Earthquakes'. Prof. Ugo Ventriglia, Director, Institute of Applied Geology, University of Rome, Rome, Italy presided over the session on 'Geological Studies of Tectonic Features Influencing Occurrence of Earthquakes'. Dr. A.N. Tandon, Director (Seismology) India Meteorological Department, New Delhi. presided over the session on 'Wave Progagation'and Seismicity'. Eighty five delegates from India, two each from U.S.A., U.S.S.R. and Italy, one each from Ceylon, Finland, U.K. and Iran attended the Symposium.

Fiftyseven papers were presented at the various technical sessions.

An exhibition of scientific instruments was arranged during the Symposium by local instrument manufacturers and outside firms. Special display of the progress of research investigations undertaken at the Earthquake School was arranged during the Symposium.

The delegates visited the other University departments, Structural Engineering Research Centre, Roorkee and Irrigation Research Institute, Roorkee, Central Building Research Institute, Roorkee, on November 7th, 1966.

The proceedings of the Symposium have been published by M/S Sahu Cement Service, P.N.B. House, 5, Parliament Street, New Delhi and can be had from them.

REVIEWS

Foundations Subjected to Vibration (Annotated Bibliography) by Shamsher Prakash and D. C. Gupta

The bibliography contains 191 references on the behaviour, design and construction of machine foundations. These are arranged subject-wise in seven differenl groups for the convenience of the user. All important publications on the subject upto date have been included.

The bibliography will be useful to the scientific workers interested in the behaviour of mechine foundations in particular and profession of civil engineering and industrial organisations in general.

NEWS OF MEMBERS

Agarwal, S. L., formerly editor of the Bulletin of the Society has proceeded to University of Texas, Austin, U.S.A. for post graduate studies.

Agrawal, P. N., has left Regional Research Laboratory, Johrat, Assam and joined Earthquake Research School, Roorkee, as scientst,

Arya, A.S., has taken over as Assistant Director Incharge of the Earthquake Research School, University of Roorkee, Roorkee.

Chandrasekaran, A.R., has been promotted to the post of Professor in Earthquake Research School, University of Roorkee, Roorkee.

Krishna, J., has proceeded to Yugoslavia on UNESCO assignment for one year. He will be helping in the establishment of the International Institute of Seismology, Earthquake Engineering and Town Planning, at Skopje in Yugoslavia.

Nagrajan, R., Bridge Engineer Southern Railway has been appointed as Director (Civil) in Indian Standards Institution, New Delhi.

Narain, J., has been appointed as Senior Professor in Civil Engineering Department, University of Roorkee, Roorkee.

Prakash, S., has been promotted to the post of Professor in Earthquake Research School, University of Roorkee, Roorkee.

INDIAN SOCIETY OF EARTHQUAKE TECHNOLOGY

Instructions for Authors

MANUSCRIPTS

1. Only papers, which have not been previously published or offered for publication elsewhere, will be considered. The authors must agree not to publish a paper elsewhere when it is under consideration and print in the Bulletin of the ISET.
2. Manuscript must be typed-written in English or Hindi with two-line spacing on one side of the paper only.
3. Three copies of the manuscripts must be submitted.
4. The paper should be limited to not more than 6000 words.
5. The use of the first person should be avoided, the writer being referred to as "the Author"
6. All mathematical symbols should be defined where they appear first in the text.
7. Drawings or sketches should not be included in or pasted on the pages of the manuscript and should be submitted separately with the paper.
8. Each article should be accompanied by an "abstract" of its subject matter, with special references to any conclusions, and it should not exceed 300 words:
9. A set of conclusions must be given at the end of the article.
10. Bibliographical references should be given as follows :—
    (a) In the text, the author's name and the year of publication or number in the list of reference cited should appear in parentheses as (Gutenberg 1959) or Gutenberg (1959), or Gutenberg (4).
    (b) In the list of reference at the end of the article, the references should be in standard form as indicated below and listed in alphabetical order of author's name, or the sequence in which they appear in text.
    Name, intials, year of publication.
    Title of work, Source (in full), volume number, page number (beginning) page number (end), date.

Example :—

Aggarwal, S.L. (1964) "Static and Dynamic Behaviour of a Vertical Pile Subjected to Lateral Loads", Master of Engineering Thesis, University of Roorkee, Roorkee, 1964.

Arya, A.S. and Y.P. Gupta, (1966), "Dynamic Earth Pressure on Retaining Walls Due to Ground Exitations", Bull., Ind. Soc. of Earthquake Technology, Vol. III, No. 2, pp. 5-16, May, 1966.

ILLUSTRATIONS

1. Drawing should be made on tracing linen or paper in dense black drawing-ink, the thickness of lines being consistent with a reduction to one half or less in the process of reproduction, details shown should represent the minimum necessary for a clear understanding of what it is desired to illustrate.
2. The maximum final size of a single drawing or a group of drawings which are intended to appear on the same page, is 7.5 inches (19 centimeters) by 5 inches (13 centimeters). Drawings should be submitted larger than final size, the ideal being twice final size i.e. upto 15 inches (38 centimeters) by 10 inches (26 centimeters).
3. It should be ensured that printing of captain in the illustration is large enough so that it would be legible after reduction to one half linear size. 3/16 inch (0.5 cm) size letters are recommended.
4. Each figure should carry a suitable title.
5. Manuscript may also be accompanied by photographs (glossy prints) which should however, represent the minimum number essential to a clear understanding of the subject. No lettering of any kind should be added to the face of a photograph, the figure number and caption being printed lightly on the reverse side or upon the front of the mounting, if mounted.
6. All illustration should be numbered consecutively without distinction between photographs and drawings. Each illustration should have an appropriate references in the text, and the figure number order should follow the order in which references appear in the text.

INDIAN SOCIETY OF EARTHQUAKE TECHNOLOGY
ROORKEE, (U.P.) INDIA

ADDRESS OF OFFICERS

President, Jai Krishna, (Professor and Director, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee, U. P., India), Present Address, UNESCO Professor, International Institute of Seismology, Earthquake Engineering and Town Planning, Skopje, Yugoslavia.

Vice-President, V. S. Krishnaswamy, Superintending Geologist, Engineering Geology Division, Geological Survey of India, Chandra Kuti, M. M. Malviya Marg, Lucknow.

Secretary and Treasurer, A. S. Arya, Professor and Assistant Director in-charge School of Research and Traininig in Earthquake Engineering, University of Roorkee, Roorkee, U. P.

Editor, L. S. Srivastava, Reader in Applied Geology, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee, U.P.