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IMPORTANCE OF EARTHQUAKE STUDIES AS PART OF ENGINEERING GEOLOGY INVESTIGATIONS IN COUNTRY-PLANNING*

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Abstract

The paper lays stress on the importance of earthquake studies in active parts of the world and emphasises the need of detalied geological investigations assisted by close net work of seismological observatories, for demarcation of the seismic belts. For earthquake resistant construction it is necessary to have the knowledge of the nature of strong ground motion near the site of a proposed structure, and the force that the structures having different dynamic characteristics will be subjected to within short distances from the epicentre. It is therefore considered essential that stations should be established to house instruments to record strong motion and response of structures having different dynamic characteristics. The data obtained will help in evaluation of seismic coefficients and theoretical and experimental studies to study the behaviour of the ground and the structure for providing adequate safe guards against damage during earthquakes.

Introduction

Earthquakes are being felt since times immemorial, and it is estimated that more than 300,000 earthquakes occur every year in various parts of the world, though only five to six thousand are felt by the people and about twenty five are classed as catastrophies. The loss of life and property has varied considerably according to the place and time of occurrence and the size of the earthquake.

Active earthquake belts cover large segments of the earth and there are few areas where earthquake problems can be totally neglected. The greatest number of earthquake foci are found to be concentrated in the Circum-Pacific belt and the belt which extends from North Africa, through Southern Europe, the Alps, South Eastern Europe and Asia Minor, to the Hindukush, Central Asia and the Himalayas, and thence to Indonesia where it joins the Circum-Pacific belt. It is in these belts that the geologists and the engineers are faced with the most challenging and continuing problem of protecting mankind by taking necessary precautions in the construction of structures and allowing earthquake forces in their design.

The fundamental aims of earthquake engineering are to prevent personal injury and loss of human life, to minimise damage to property and to ensure the continuity of vital services in the event of earthquake. Usually structures are designed by taking in certain proportion of its weight (usually 10% g) acting at its centre of gravity as equivalent to an earthquake force and many structures designed on this thumb rule have withstood shocks of moderate size. This thumb rule has limited application and it is desirable that design of seismic coefficients for structure are estimated after consideration of the seismicity of the site, dynamic response characteristics of the structure including the interaction of the structure and the sub-soil, energy absorption or damping of the structure, properties of structural materials, bearing capacity of the soils and other factors which control the over all behaviour of the structure and the importance of the structure as related to its use and permitted degree of damage. Thus to arrive at a conservative estimate of the design seismic

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coefficients and proper site selection, in addition to the data of the characteristics of the structures and construction material, adequate knowledge of strong ground motion data on past earthquakes and resulting damage and geographic, geotectonic, geological and sub-soil condition is essential.

Seismicity

Seismicity is a term used to describe the form and status of earthquake activity in an area. Data on geology, tectonics, and the frequency, epicentral distribution, magnitude and intensity of past earthquakes form the basis in expressing the earthquake risks involved; and various kinds of maps are prepared to evaluate the probability of occurrence of earthquake and its likely maximum intensity in the area.

Unfortunately, systematic records of earthquakes have been obtained only since very recent times. Before the advent of instrumental measurements, it is only the very devastating shocks that are mentioned in historical records. Detailed descriptions are available only for earthquakes that have occured in the present century. and records of thousands of earthquakes which may have occurred earlier are not available. At present more than four hundred seismograph stations are operating in the various parts of the world. But even now many small tremors, orginating from the potential active zones along which a devastating earthquake could occur in future, are missed, as the net work of the stations is not close enough and the waves die off before they reach a recording station. A closer net work of seismograph stations would thus be very helpful in the study of active belts by recording greater number of smaller shocks occurring frequently for country planning (4).

In many cases, in the absence of seismic data it is difficult to demarcate the active belts and prepare seismic zoning maps. In such cases data on tectonics of the region can be utilised as seismicity has close correlations with geology and tectonics, The application of this correlation is not fully understood and is complicated. Still, it is necessary to study not only the present existing geological structures, but also the complete history of the tectonic evolution of the area, through the various geological ages and with particular reference to the recent differential movements of the crust. Geological mapping, geophysical surveys, geomorphological data and geodetic measurements assisted by seismological records thus help in recognising and demarcation of the active faults and zones of differential movements along which earthquakes can be expected to occur in future.

Strong Motion Earthquake Study

There are two principal types of seismograph stations in common use, generally referred as 'teleseimic' and 'local'. The primary purpose of the teleseismic stations is to record earthquakes from long distances. The main problems of study at such stations are delineation of areas of high seismicity, crustal structure, interior of the earth, mechanism of earthquakes and tsunami warning. Although the larger earthquakes can be recorded at very great distances from their foci, but their study alone is insufficient for the proper understanding of the processes involved. Small earthquakes are proportionately more common than the larger ones, and their study often allows a more rapid determination of the nature and extent of an active belt as compared to the major shocks. Local stations are thus very essential and are more helpful in determination of the pattern of seismicity and its correlation with geology, regional crustal structure, precise magnitude and epicentre of the earthquakes, ground movements in the epicentral tracts, general character of ground formations and the vibration characteristics of the ground motion.

The seismograph station maintain sensitive seismographs and the requirements of the various studies need these instruments to be located on firm ground (preferably rock) isolated from inhabited areas to avoid disturbances caused by local effects. If a strong motion, enough of engineering significance occurs within 50 to 100 kms. radius of these sensitive instruments they are thrown off the scale and cease to function. Such stations do not thus provide adequate data for engineering studies.

For the design of earthquake resistant buildings, factories, bridges, dams etc. an engineer requires data of true ground movements and acceleration due to earthquakes within a distance of 50 to 100 kms. from the site of the proposed structure, and also the response of structures to these movements, because this earthquake only could damage the structures that are to be designed and constructed. Special strong motion instruments, are therefore necessary, to record the character of these movements for the correct determination of stresses and deformations produced. These would also be helpful in evaluating the influence of the local geological conditions on the earthquake motion.

The strong motion measurements are made on accellerographs (2). The true ground motion recorded as a function of time by the accellerograph (Fig. 1) help in determining the response of the structure and the preparation of response spectrum curves (1).

The desirable natural period of vibration of the accelerograph is about 0.05 second, but periods not greater than 0.10 second are acceptable for general use. Where it is known that short period motions are not important, the period may be kept as high as 0 15 second. The range of the accellerograph should be such that it can satisfactorily record a maximum acceleration of 1 0 g, and should be sensitive enough to accurately measure the smallest earthquake of engineering significance. The damping of the accelerometer element should not be less than 60% of the critical The recording speed should not be less than 10 mm per sec., and it is desirable that a uniform speed is maintained with an accuracy of the order of 5%. As strong motion earthquakes generally occur at intermittant intervals and due to the high speed of recording, continuous running of the accelograph is not possible and the instruments require a starting mechanism which must be triggered by the earthquake itself, with the recording paper drive initially at rest. The time delay between rest and full recording speed should not be greater than 0.1 to 0.2 seconds so that greater parts of the initial motions are not missed. The time duration of the record must be at least 30 seconds and the instrument should contain an automatic reset to return the instrument to readiness for the next earthquake. A sufficient supply of recording paper should be included to permit at least two repetitions of the recording cycles before servicing. The operating power of the accelerograph must be independent of local electric supply, which may be used for such purposes as charging of batteries. In the design of the accelerograph, due consideration should be given to the ease of installation and of maintenance in proper operation condition. It should also be kept in mind that such instruments may often have to be checked and serviced by relatively unskilled personnel.

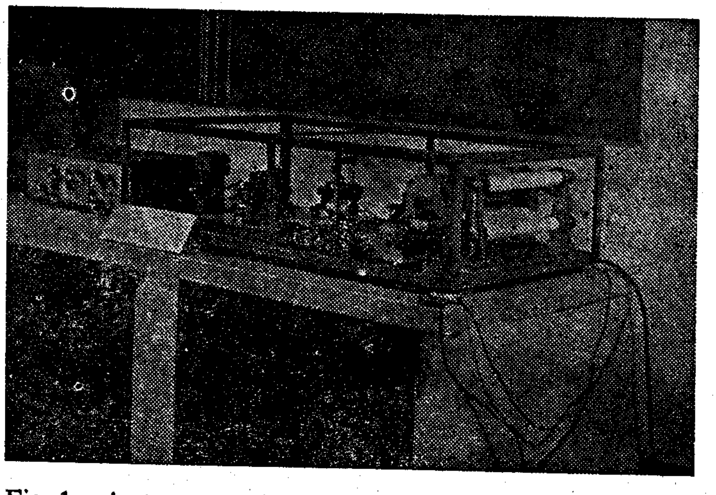

Fig. 1. A strong motion Acclerograph to measure strong ground motian

The accelerographs should be installed in a closer net work as compared to the standard seismograph net works, so that it can record ground motion of sufficient magnitude to be of engineering interest within 50 to 100 kms. of the epicentre of strong earthquakes. Also the magnitude of the ground motion may be strongly modified by local geological conditions which could change at very short distances, and therefore it is desirable to install the instruments in the geological and soil environments in which the engineering structures are envisaged to be built, since it would be very difficult and expensive to completely cover all the seismic regions with an entirely adequate net work of accelerographs.

Because of the relatively high cost and complexity of the strong motion accelerograph, and the necessity for obtaining more information of the effects of local geological conditions and greater instrumental coverage of seismic areas, a low cost simplified strong motion earthquake recorder has been developed, which has been termed as Structural Response Recordes (3). This recorder does not directly measure ground motion, but rather records the maximum response of a mechanical system idealising the two major dynamic characteristics (natural period of vibration and damping) which affects the over all behaviour of a structure. The natural period and damping of the recorder element can be made similar to the period and damping of the important structures in the region in which the recorder is to be used. Typical values of natural periods which have been used are from 0.25 to 1.25 seconds and the usual values of damping are from 5 to 10% of critical. A group of structural response recorders installed in the vicinity of an accelerograph will give increased information on effects of the local geology and soil conditions.

It is useful to design structural response recorders with multiple elements, covering a range of periods and damping The recorders (Fig. 2) being installed in India consist of six elements having the following characteristics :

Pendulum No.	Period second	Damping % of critical
1	0 40	5
2	0.75	5
3	1 25	5
4	0.40	10
5	0.75	10
6	1.25	10

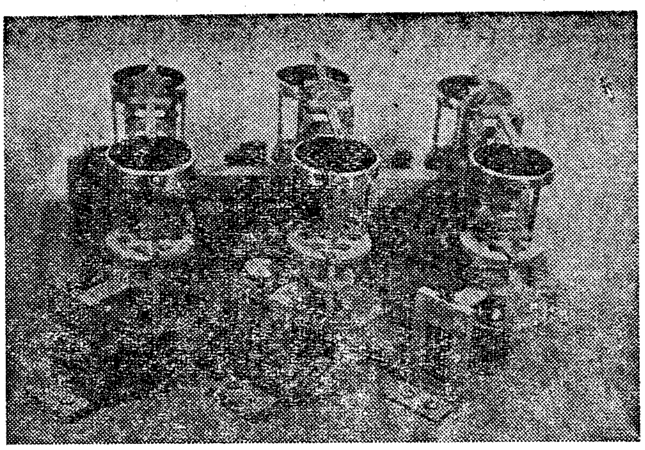

Fig. 2. Structurl Response Recorders designed and manufactured at the Earthquake School, Roorkee, India Structural Response Recorders have been installed at 37 stations in the seismically active part of India. Each set consists of six pendulums having different period of vibration and damping so that a fairly good idea of the response of the idealised structures during a strong earthquake can be obtained.

The record so obtained on the six elements directly give points on the response spectrum curves relating natural period, damping and response of the structure. This data is directly useful for design of structures with properties simulated in the recorder.

The reading of the recorders can be correlated in an approximate way with seismic intensity scales, as it takes into account the geological characteristics of the area which affect the propagation of waves and the effects due to the interaction between the ground, earthquake waves and the structures. The observed data hence provide a way of introducing an improved quantitative significance into such scales.

Prediction of Earthquakes

It would be praise worthy effort if it would be possible to predict earthquakes with respect to the place of occurrence, time and its size. The work involved in this problem however, presents great difficulties, huge expenditure and is very difficult to achieve in the

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SEISMOLOGICAL NOTES

(India Meteorological Department, New Delhi)

Earthquakes in and near about India during July—December, 1967

Date 1967		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
July	2	07	03	55 (SHL)	9.0	93.4	Nicobar Islands	—	6 2 (NDI)	—
		07	03	52.9 (CGS)	8.7	93.8	Nicobar Islands	33	5.7 (CGS)	—
July	2	08	32	38.5 (CGS)	33.2	75.6	Eastern Kashmir	33	4.8 (CGS)	Felt at Jullundhar and some other areas of Punjab.
July	2	14	09	37.6 (CGS)	8.5	93.8	Nicobar Islands	36	5.2 (CGS)	—
July	2	14	19	13.6 (CGS)	8.5	93.8	Nicobar Islands	33	4.9 (CGS)	—
July	2	18	36	18.9 (CGS)	8.6	93.8	—do—	33	4.5 (CGS)	—
July	7	22	56	30.8 (CGS)	27.8	92.2	India-China Border Region	33	4.9	—
July	7	23	49	23.6 (CGS)	35.5	87.8	Tibet	33	—	—
July	16	07	44	15 (SHL)	23.5	87.5	—	—	—	—
July	19	17	28	32.2 (CGS)	36.5	70.3	Hindukush Region	223	4.7 (CGS)	—
July	23	01	16	42.2 (CGS)	36.9	71.4	Afganistan USSR border	180	4.6 (CGS)	—
July	25	15	50	25 (NDI)	28.8	77.3	16 kms. N E of Delhi Observatory	—	—	Felt in Delhi.
July	28	17	27	33.7 (CGS)	2.1	98.0	Northern Sumatra	32	3.1 (CGS)	—
July	29	14	12	18.9 (CGS)	35.5	70 8	Hindukush Region	194	4.6 (CGS)	—
Aug.	4	08	06	59.1 (CGS)	34.8	70.1	Afganistan	33	4-8 (CGS)	—
Aug.	6	10	31	06.3 (CGS)	38.0	74.5	Tadzik Sinkiang Border	215	4.8 (CGS)	—

1	2	3	4	5	6	7	8	9	10
Aug. 7	05	49	57.5 (CGS)	36.5	71.2	Afganistan USSR Border	229	5.0	—
Aug. 11	01	57	05 (NDI)	16	80	Andhra Pradesh	—	—	—
Aug. 12	22	54	38.6	37.0	71.4	Afganistan USSR Border Region	121	5.1	—
Aug. 14	06	41	46.2	5.4	96.6	Northern Sumatra	33	5.2	—
Aug. 15	07	40	28.7 (CGL)	36.3	70.2	Hindukush Region	189	4.7 (CGS)	—
Aug. 15	09	21	02.3 (CGS)	31.1	93.7	Tibet	33	5.7 (CGS)	—
	09	21	00 (NDI)	31.0	93.5	Tibet	—	—	—
Aug. 16	19	18	57.6 (CGS)	0.9	98.9	Northern Sumatra	26	5.6 (CGS)	—
Aug. 19	01	34	43.5 (CGS)	36.9	71.5	Afganistan USSR Border Region	127	4.9 (CGS)	—
Aug. 20	17	19	35.0 (CGS)	37.1	95.7	Tsinghai (China)	33	4.5 (CGS)	—
Aug. 21	07	33	00.6 (CGS)	3.6	95.8	Off W. Coast of Northern Sumatra	33	5.9 (CGS)	—
	07	33	00 (NDI)	4.6	95.4	—	—	6.2 (NDI)	—
Aug. 22	07	32	57.0 (CGS)	5.8	96.2	Northern Sumatra	24	—	—
Aug. 24	01	17	09.6 (CGS)	35.3	88.0	Tibet	31	4.5 (CGS)	—
Aug. 27	04	49	59.7 (CGS)	36.3	71.1	Afganistan USSR Border Region	225	4.5 (CGS)	—
Aug. 27	11	11	57.2 (CGS)	23.1	94.2	Burma India Border Region	61	4.5 (CGS)	—
Aug. 28	21	05	51.7 (CGS)	36.5	80.1	Southern Sinkiang China	33	4.7 (CGS)	—
Sep. 6	01	43	31.8 (CGS)	24.1	91.7	India-East Pakistan Border Region	18	5.0 (CGS)	—
Sep. 6	07	30	10.8 (CGS)	14.7	93.6	Andaman Island Region	33	5.6 (CGS)	—
	07	30	10 (NDI)	14	94	—do—	—	—	

1		2	3	4	5	6	7	8	9	10
Sep.	8	00	26 (CGS)	02.5	36.9	71.5	Afganistan USSR Border Region	111	5.0 (CGS)	—
Sep.	8	05	23 (CGS)	40.5	38.4	70.5	Afganistan USSR Border Region	14	4.9 (CGS)	—
Sep.	11	06	12 (CGS)	00.5	27.5	66.4	W. Pakistan	36	4.6 (CGS)	—
Sep.	13	06	23 (NDI)	31	17.4	73.7	Near Koyna Dam in Maharashtra	4	5.8 (NDI)	Caused some damage in Koyna Nager and neighbourhood. Felt over a wide area upto Bombay. These earthquakes were preceeded and followed by a large number of smaller shocks.
Sep.	13	06	48 (NDI)	25	17.4	73.7	—do—	—	5.6 (NDI)	
Sep.	15	10	32 (CGS)	48.7	27.4	91.8	Bhutan	57	5.8 (CGS)	—
		10	32 (NDI)	46	27	92	Bhutan	—	6.0 (NDI)	—
Sep.	18	08	26 (CGS)	36.7	35.9	70.4	Hindukush Region	140	4.8 (CGS)	—
Sep.	20	20	25 (CGS)	05.8	32.6	76.1	Kashmir-H.P. Border Region	59	4.1 (NDI)	Felt at Jullundur.
Sep.	22	20	09 (CGS)	13.3	31.9	94.6	Tibet	33	—	—
Sep.	22	22	11 (CGS)	48.3	36.2	71.4	Afganistan USSR Border Region	127	4.7 (CGS)	—
Oct.	2	17	49 (CGS)	51.3	37.6	72.1	Tadzik SSR	105	4.3 (CGS)	—
Oct.	13	03	24 (CGS)	47.0	39.7	74.4	S. Sinkiang Province China	33	5.2 (CGS)	—
Oct.	18	00	55 (CGS)	07.3	23.4	94.9	Burma-India Border Region	54	4.8 (CGS)	—
Oct.	21	11	00 (CGS)	35.9	31.6	99.9	Szechwan Province, China	33	5.2 (CGS)	—
Nov.	3	16	40 (CGS)	48.6	39.8	77.5	S. Sinkiang Province, China	33	4.5 (CGS)	—
Nov.	7	19	57 (CGS)	26.1	37.0	71.7	Afganistan-USSR Border	136	5.3 (CGS)	—
		19	57 (SHL)	30	36.0	70.0	Hindukush	—	5.5 (NDI)	—

1		2	3	4	5	6	7	8	9	10
Nov.	10	06	04 (CGS)	09.4	25.5	91.7	India-East Pakistan Border	59	4.4 (CGS)	—
			—			—	—	—	5.5 (NDI)	—
Nov.	12	12	32 (CGS)	43.4	6.1	95.2	Nicobar Island	105	4.7 (CGS)	—
Nov.	14	00	04 (CGS)	17.8	24.0	91.5	India-East Pakistan Border	33	5.1 (CGS)	—
		00	04 (SHL)	34	26.0	91.0	Garo Hills	—	5.3 (NDI)	—
Nov.	16	00	41 (GCS)	24.7	37.6	69.7	Afganistan-USSR Border	33	4.7 (CGS)	—
Nov.	29	05	19 (GCS)	00.7	36.4	70.8	Hindukush	228	4.8 (CGS)	—
Dec.	4	21	41 (CGS)	50.9	2.8	65.1	Carlsberg Ridge	33	49 (CGS)	—
Dec.	9	04	56 (CGS	14.3	36.3	70.8	Hindukush	225	4.8 (CGS)	—
Dec.	10	18	43 (CGS)	34.4	22.5	94.8	Burma	158	5.2 (CGS)	—
Dec.	10	22	51 (CGS)	24.3	17.4	73.9	Koyna Nagar	33	6.0 (CGS)	Koyna Nagar Township razed to the ground. 177 people killed and 2300 injured. Felt over a large area in Peninsular India (A special note on this earthquake appears in the journal Vol. No. 4)
		22	51 (NDI)	19.0	17.37	73.74	3 kms South of Koyna Dam	8	7.5 (NDI)	NDI magnitude given are determined from Standard Wood Anderson seismograms from Indian Observatories
Dec.	10	23	52 (CGS)	16.7	17.4	73.7	Aftershock of Koyna Earthquake	33	5.0 (CGS)	—
Dec.	11	20	49 (CGS)	48.5	17.3	73.7	Aftershock of Koyna Main Earthquak	11	5.2 (CGS)	—
		20	49 (NDI)	47.5	17.27	73.68	—	—	5.8 (NDI)	—
Dec.	12	03	22 (CGS)	32.3	6.7	61.5	Carlsberg Ridge	33	—	—
Dec.	12	06	18 (CGS)	37.9	17.6	73.9	Aftershock of Koyna Earthquake	29	5.4 (CGS)	—
		06	18 (NDI)	33.5	17.29	73.65	—	—	6.2 (NDI)	—

1	2	3	4	5	6	7	8	9	10
Dec. 12	15	48 (CGS)	55.5	17.4	73.9	Aftershock of Koyna Earthquake	27	5.0 (CGS)	—
	15	48 (NDI)	51.7	17.29	73.63	—	—	5.9 (NDI)	—
Dec. 13	05	09 (NDI)	41.8	17.31	73.68	Aftershock of Koyna Earthquake	—	5.5 (NDI)	—
Dec. 13	19	19 (NDI)	45.5	17.50	73.62	Aftershock of Koyna Earthquake	—	5.6 (NDI)	—
Dec. 14	19	15 (CGS)	20.5	38.2	91.3	Tshinghai Province China	33	5.4 (CGS)	—
Dec. 17	00	25 (CGS)	15.1	36.5	71.4	Afganistan-USSR Border	82	5.2 (CGS)	—
Dec. 19	03	23 (CGS)	49.6	37.5	72.0	Tadzhik SSR	89	5.5 (CGS)	—
Dec. 20	11	34 (CGS)	25.9	11.8	93.0	Andaman Island	61	5.4 (CGS)	—
Dec. 21	23	43 (CGS)	11.4	11.8	93.1	Andaman Island	33	5.0 (CGS)	—
Dec. 24	23	49 (CGS)	53.9	17.5	73.9	Aftershock of Koyna Earthquake	33	5.5 (CGS)	—
	23	49 (NDI)	51	17.35	73.71	—	—	5.8 (NDI)	—
Dec. 25	17	37 (CGS)	39.1	17.2	73.9	Aftershock of Koyna Earthquake	33	5.1 (CGS)	—
Dec. 28	10	28 (NDI)	04.3	—	—	22 kms from Delhi	—	2.7 (NDI)	Felt at Delhi
Dec. 28	20	15 (CGS)	48.6	37.2	71.8	Afganistan-USSR Border	156	4.7 (CGS)	—
Dec. 29	06	24 (CGS)	50.3	36.3	70.2	Hindukush	230	4.7 (CGS)	—
Dec. 30	12	36 (CGS)	55.8	31.7	86.8	Tibet	24	4 9 (CGS)	—

INTERNATIONAL CONFERENCE ON SHEAR TORSION AND BOND IN REINFORCED AND PRESTRESSED CONCRETE

14—17 January 1969

The International Conference on Shear, Torsion and Bond in Reinforced and Prestressed Concrete sponsored by the PSG College of Technology, University of Madras and the Structural Engineering Research Centre, Council of Scientific and Industrial Research, Government of India, will be held during the 14th to 17th of January 1969 at the PSG College of Technology, Coimbatore-4, India.

Original papers, not published previously and having a direct bearing on the subject of the Conference, are invited from all over the world.

Proposals from authors containing short title of paper, name, position and address of author/s together with a summary—short but sufficient in detail for evaluation and acceptance—should be sent to reach before 31st July 1968. Authors will be notified of acceptance before 15th September 1968. Complete manuscripts, prepared in conformity with the publication details that will be sent along with the acceptance notification, should reach the Organizing Secretary before 15th November 1968.

All accepted papeas whether presented orally or not will be included in the Conference Proceedings to be published later.

All communications may please be addressed to

Dr. V. Ramakrishnan
Organizing Secretary
Professor and Head, Department of Civil Engineering
PSG COLLEGE OF TECHNOLOGY
COIMBATORE-4, INDIA

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 cnusideration 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 caption 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 fiure 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 illustrations should be numbered consecutively without distinction between photographs and drawings. Each illustration should have an appropriate reference in the text, and the figure number order should follow the order in which references appear in the text.

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