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RECOMMENDATIONS FOR SEISMIC INSTRUMENTATION FOR RIVER VALLEY PROJECTS

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RECOMMENDATIONS FOR SEISMIC INSTRUMENTATION FOR RIVER VALLEY PROJECTS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 17 November 1968, after the draft finalized by the Earthquake Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Evaluation of seismic status of faults and thursts and collection and maintenance of seismological data both in preconstruction as well as postconstruction stages of a river valley project are of vital importance because of safety reasons. In addition to permanent installation of instruments within the dam and appurtenant structures and in the surrounding areas, the study of microtremors and predominant period with temporary instruments as given in detail under **3** will be supplementary and may be regarded as a part of the site investigations for selecting the best suitable type of foundation.

0.2.1 The recommendations given in this standard may, however, also be used for investigation of seismicity of site for any project besides river valley projects, if the situation and the magnitude of the project justifies so.

0.3 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard covers recommendations for (a) instrumentation for investigation of seismicity, (b) study of microtremors and predominant period of a dam site and (c) permanent installation of instruments in the dam and appurtenant structures and in the surrounding areas.

*Rules for rounding off numerical values (*revised*).

2. INSTRUMENTATION FOR INVESTIGATIONS OF SEISMICITY

2.1 Distribution of Earthquake Epicentres in the Vicinity of the Site (Particularly of Those Which are not Felt by People) — Five observatories shall be set up around the site, of which at least one shall be the main observatory and the other subsidiary observatories. The main observatory shall be located near the proposed site and the subsidiary observatories around it. The spacing of observatories shall not exceed 70 km.

2.1.1 The siting of the main and subsidiary observatories will, however, require consideration of the geological structures and soil characteristics of the area.

2.1.2 It is desirable that this set up of observatories as recommended in **2.1** should be installed at least five years before the design stage of the project. The setting up of a comprehensive network requires some time before it becomes fully operative. In order to meet the demands for an early commencement for the recording of the seismic events, provision should be made for an early setting up of the main observatory, so that the general level of seismicity at a project site may be monitored ahead of the installation of the full network.

2.1.3 The instrument room of the observatories shall be so constructed that the diurnal temperature variations inside the room are not more than 5°C.

2.1.4 A recommended layout for observatory buildings and their functional requirements are given in Appendix A.

2.2 Instruments for Main Observatory — The instruments given in **2.2.1** to **2.2.4** shall be installed in the main observatory.

2.2.1 *One Complete Set (Two Horizontal and One Vertical) of Short Period High Magnification Electromagnetic Seismographs* — The seismograph period shall be one second and galvanometer period shall be 1/10 to one second. The magnification of the seismograph should preferably be greater than 10^4. The recorders for these instruments shall give a paper speed of not less than 60 mm/min (*see* Note).

NOTE — The magnification suitable for a particular site depends largely on the seismic noise of the site.

2.2.2 *Two Components of Standard Wood-Anderson Type Torsion Seismograph* — Its period shall be 0·8 s, damping 0·8, magnification 2 800 and a recording speed of not less than 60 mm/s (*see* Note).

NOTE — Instruments of magnification other than 2 800 may also be installed; the recorded amplitude in such cases would, however, require appropriate correction.

2.2.3 *One Accelerograph (With one Vertical and Two Horizontal Components)* — They shall have the following specifications:

a) Natural free period	1/15 to 1/20 s
b) Damping	60 to 70 percent
c) Range	Usually g, $\frac{1}{2}g$ and $\frac{1}{4}g$ (*see* Note)
d) Sensitivity	An amplitude of 4 cm on paper corresponding to the maximum acceleration specified in (c) above

NOTE — The recommended accelerations are given below depending upon the seismic zone in which the site is located:

Location of Site	*Acceleration*
Zones V and VI according to IS : 1893-1966*	g
Zones III and IV according to IS : 1893-1966*	$\frac{1}{2}g$
Other zones	$\frac{1}{4}g$

2.2.3.1 *Starting mechanism* — The accelerographs shall be actuated by a starting mechanism coming automatically into operation when the ground motion begins and shall automatically stop not less than 5 seconds after the last contact (*see* Note).

NOTE — The recording speed shall not be less than 10 mm/s. It is desirable to have higher recording speeds.

2.2.3.2 *Timing device* — There shall be a timing device to obtain the time base on the records.

2.2.3.3 *Storage batteries* — The accelerographs shall be operated by storage batteries which should be charged continuously by a tricle charger.

2.2.4 *Sets of Structural Response Recorders* — These are dynamic models of structures. They shall be installed at the ground level. (To be founded at the same level as the structure which this recorder is supposed to model.) In no case they shall be installed at different heights of a structure.

The recorders should have period and damping ranges as that of the structures to be located in the area. It is better to install similar recorders of varying sensitivity. The instruments may have different period (covering the range between 0·2 to 3·0 s) and damping (2 to 20 percent).

2.3 Instrument for Subsidiary Observatory — The instruments given in **2.3.1** to **2.3.3** shall be installed in the subsidiary observatory.

*Criteria for earthquake resistant design of structures (*revised*). **(Third revision in 1975[1]).**

2.3.1 *One Vertical Component Short Period High Magnification Electromagnetic Seismograph* — The specifications of this instrument should preferably be the same as those under **2.2.1**.

2.3.2 *Two Components of Standard Wood-Anderson Type Torsion Seismograph* — The same specifications as in **2.2.2**.

2.3.3 *Sets of Structural Response Recorders* — The same specifications as in **2.2.4**.

2.4 There shall be proper arrangement at each observatory for accurate recording of time signals. The absolute time measurement shall be correct at least upto $\pm 0{\cdot}1$ second. The use of electronic clocks for time recording as well as for the power source used for running the recording drum of the various instruments mentioned, is recommended.

2.5 There shall be suitable arrangements for automatic switching over to alternative power source from storage batteries or generators for running the instruments in the event of failures of main power supply.

2.6 All the seismographs shall be installed on concrete pillars founded preferably on hard rock and the site shall be away from sources of disturbance, such as heavy traffic and heavy machines. In case the hard rock is not available near the site the pillar shall be constructed on consolidated foundation.

3. STUDY OF MICROTREMORS AND PREDOMINANT PERIOD OF THE SITE (MOBILE SET UP)

3.1 It would be desirable to record microtremors at the site by using high sensitivity short period seismographs having a magnification of the order of 10^5. This record shall be used to bring about the predominant period likely to be experienced at the site and the frequency of their occurrences. These investigations should be carried out for about a week. During this week records shall be taken at different times in a day.

4. PERMANENT INSTALLATION OF INSTRUMENTS IN THE DAM TO MEASURE EARTHQUAKE EFFECTS

4.1 Accelerographs with specifications same as those under **2.2.3** shall be installed in the dam at the base (in gallary near the foundation) and at the top of the dam. If the height of the dam exceeds 100 m, one accelerograph shall also be installed near the mid-height of the dam. The accelerograph locations may be suitably selected to avoid the background seismic noise created due to the vibrations originating from the appurtenant works of the dam.

4.2 Displacement meters shall be installed at the same locations as the accelerographs. These shall have long period (more than 2 seconds) with damping nearly critical and shall be actuated by the accelerograph starting mechanism.

4.3 Dynamic water pressure gauges may be installed on the up stream face of the dam (below the minimum draw down level and above the silt level). The dynamic pressure measuring range of the gauges shall not be less than the corresponding hydrostatic head. The gauge shall be actuated by the accelerograph starting mechanism.

4.4 Structural response recorders having periods and damping ranges as that of the prototype structures (monoliths, intake structures, etc) shall be installed at the ground level near the structure.

4.5 Based on the importance of the project the installation of the following instruments may be desirable at one or more sites:

a) Silica tube extensometer,
b) Tilt meters of both water tube, and horizontal pendulum type, and
c) Seiche recorders.

APPENDIX A

(*Clause* 2·1·4)

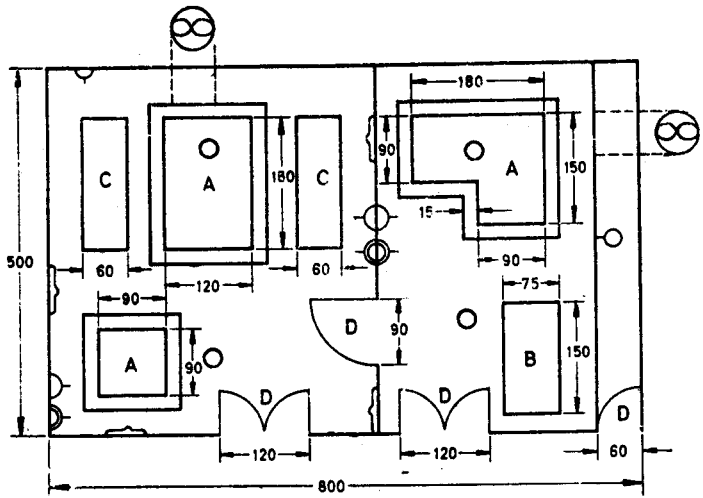
RECOMMENDED LAYOUT FOR THE OBSERVATORY BUILDINGS AND THEIR FUNCTIONAL REQUIREMENTS

A-1. FUNCTIONAL REQUIREMENTS

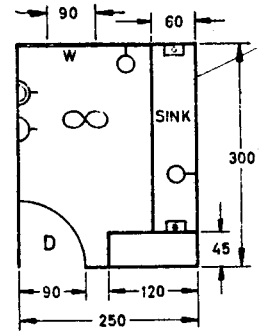
A-1.1 The seismological observatory buildings should be designed and constructed so as to provide for the functional requirements as given in **A-1.1.1** and **A-1.1.2.**

A-1.1.1 *Main Observatories* — These should have the following:

a) An instrument vault of the size 8 × 5 m partitioned by a wall reaching the ceiling into two rooms. Details of the partitioning and other provisions inside the vault are shown in the Fig. 1A.
b) An office room of size about 4·5 × 4·5 m.
c) A room 3 × 2·5 m for photographic work. Details of provisions in this room are shown in Fig. 1B.
d) One store room 3·5 × 3 m.
e) Bath and W.C.
f) Verandah.



1A Typical Layout for Main Observatory



1B Typical Layout for Photographic Room

D — 5 Amp Light Plug

O — Pendent Light

∞ — Fan

O— — Bracket Light

A — Seismograph Pillar

C — Slab for Recorder

D— — 15 Amp Power Plug

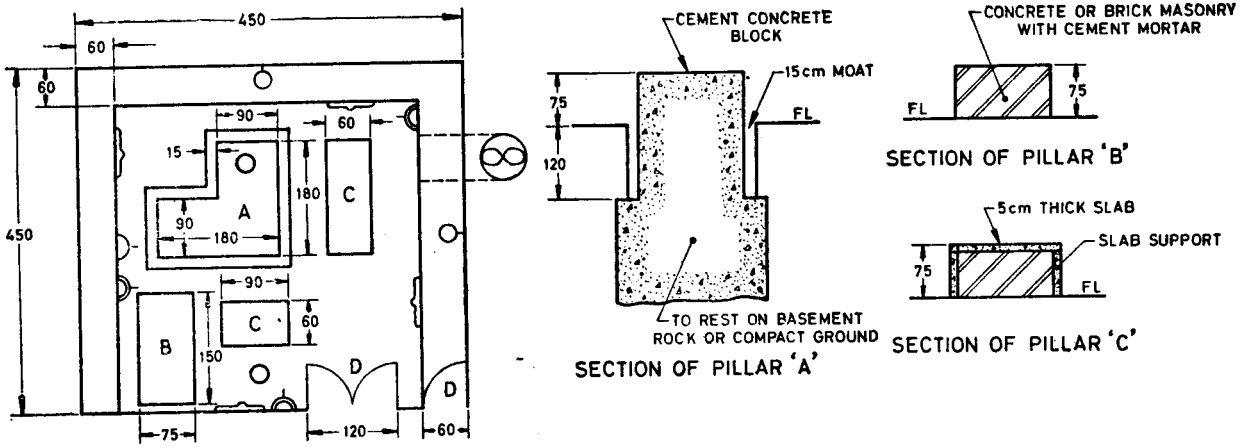
[— Safe Light

— Exhaust Fan

} — Ruby Red Foot-Light (to be Fixed 15 cm above the Floor Level)

B — Accelerograph Pillar

D — Door



IC Typical Layout for Subsidiary Observatory

All dimensions in centimetres.

FIG. 1 TYPICAL LAYOUT FOR OBSERVATORY BUILDINGS

A-1.1.2 *Subsidiary Observatories* — These should have the following:

a) An instrument vault of size 4·5 × 4·5 m with pillars and other provisions as shown in Fig. 1C.

b) One office room about 4·5 × 3·5 m.

c) One photographic room as given in **A-1.1.1.**

d) One store room 3·5 × 3 m.

e) Bath and W. C.

f) Verandah.

A-2. OTHER REQUIREMENTS

A-2.1 The following further conditions need be satisfied by the construction.

A-2.1.1 The instrument vault should be protected from direct sun rays to minimize temperature fluctuation inside. The nature of this protection depends on the site of the observatory. For example, if the observatory is located on the slope of a hill, it may be possible to construct the vault in a drift with the other rooms in front of it. In such a construction, the vault gets protected on all sides except the top. If, however, the observatory site is on level or gently sloping ground, the vault may be flanked on as many sides as possible by the other rooms. The sides which remain exposed should be protected by providing a 60 cm wide dead air space around as shown in Fig. 1C. In addition to the roof a false ceiling of heat insulating material may be provided about 30 to 60 cm below the roof.

A-2.1.1.1 In general an underground structure for the seismograph room should be preferred to an overground structure. The other rooms may be built over it.

A-2.1.2 The instrument pillars should be constructed with a rich mixture of cement concrete as a single solid block resting on unweathered bed rock. Where no rock is available it should rest on hard foundation. The section of the pillars in Fig. 1 shows the other particulars. All seismograph pillars should be provided with moats about 15 cm in width and 120 cm deep as shown in Fig. 1C. The moat may be filled with dry sand or tar.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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