No.1

REPORT OF THE

GROUP OF EXPERTS

ON

SEISMIC SAFETY OF TEHRI DAM

CONSTITUTED

BY

GOVERNMENT OF INDIA

MINISTRY OF POWER

VOLUME- II

NEW DELHI

FEBRUARY 1998

(VOLUME - II)

ANNEXURES TO VOLUME-I

ANNEXURE-1

[illegible]

[illegible]-110001 25.05.1996

NEW DELHI - 110001

Sir,

The Government have decided that the following Group of experts would examine the relevant scientific and technical reports and other information relating to the safety of the Tehri Dam:

(1) Prof. V.K. Gaur
(2) Prof. K.N. Khattri
(3) Prof. R.N. Iyenger
(4) Prof. Ramesh Chander

This information will be made available to this Group in the Ministry of Power, Shram Shakti Bhawan, Rafi Marg, New Delhi. The Ministry will make all necessary arrangements for the examination of these reports and information. Shri A.K. Agnihotri, Director, Ministry of Power would be incharge of making all necessary arrangements for this Group. The recommendations of this Group will be made available within 3 months time. These recommendations will be considered carefully by the Govt and all necessary steps would be taken to ensure the safety of dam.

All expenditure on the travel, stay etc. of the Group will be borne by the Tehri Hydroelectric Development Corporation.

Yours faithfully,

(P. Abraham)

Prof. V K Gaur
Prof K N Khatri
Prof R N Iyengar
Prof Ramesh Chander

cc: Shri Sunderlal Bahuguna.
Shri B.N. Yugandhar, Secretary to PM

(P. Abraham)

Copy for information to Shri M.D. Jayal, c/o Industrial Development Services, M-1, Kanchanjunga Building, 18, Barakhamba Road, New Delhi-1.

ANNEXURE-2

Sudhakar Rao
संयुक्त सचिव
JOINT SECRETARY

भारत सरकार
GOVERNMENT OF INDIA
विद्युत मंत्रालय
MINISTRY OF POWER
श्रम शक्ति भवन, रफी मार्ग
SHRAM SHAKTI BHAWAN, RAFI MARG.
नई दिल्ली - 110001
New Delhi - 110001

D.O. No.7/9/95-Hydel.II   2nd August, 1996

Dear

A Group of experts, recommended by Shri Sunderlal Bahuguna, is to examine the available scientific and technical reports and other information and data relating to the safety of the Tehri Dam. The list of five experts suggested by Shri Bahuguna, which includes your name, is as follows:

1) Prof. V.K. Gaur
2) Prof. K.N. Khattri
3) Prof. R.N. Iyengar
4) Prof. Ramesh Chander
5) Prof. M.C. Nigam

All materials and information will be made available to the experts in the Ministry of Power at Shram Shakti Bhavan, Rafi Marg, New Delhi. Shri A.K. Agnihotri, Director in Ministry would be incharge of making arrangements for this Group. The recommendations of this Group will be made available within 3 months time.

The first meeting of the expert group is scheduled to be held at 10.00 A.M. on 5th August, 1996, in Committee Room No.211, Second Floor, Shram Shakti Bhavan, Rafi Marg, New Delhi.

This letter is to request you to participate in the first meeting of the experts.

All expenditure on the travel, stay etc. of the Group will be borne by the Tehri Hydroelectric Development Corporation. You are, therefore, requested to indicate your travel programme and also whether arrangements for your stay need to be made by us. Similarly, it may kindly be indicated if arrangements for your travel are to be made by us. If so, you may contact Shri S.K. Jaitly, Administrative Officer, Tehri Hydro Development Corporation, Vikram Tower, Rajendra place, New Delhi - 110008 (Phone NO. 5720559 (Office), 731886 (Residence); Fax No. 5720178) directly for the tickets. In case you will be making your own travel arrangements, reimbursement of expenditure would be made by

Cont...P/2...

THDC, if you so desire.

(You may recall that I had spoken to you on this subject on 31st July, 1996. I had mentioned to you that the short notice for you for the meeting is the result of Shri Bahuguna suggesting your name separately, after recommending the names of other experts so that the group would have at least two engineers apart from the three seismologists. This suggestion was accepted by the Government, after due consideration).

A line confirming your availability for the meeting would be appreciated.

Yours sincerely,

(Sudhakar Rao)

Prof. M.C. Nigam,
Vice-Chancellor,
Goa University,
Panaji,
GOA.

Copy to:-

Shri N.D. Jayal, C/O Industrial Development Services, New Delhi. This is in continuation of this Ministry's letter of even number dated 1.8.96. Prof. M.C. Nigam telephoned today and mentioned that he is reconsidering his earlier decision and request that he may be formally approached whereafter he would decide.

(A.K. Agnihotri)
Director

Copy for information to:_

1. PM Office, (Shri Pankaj Saran, Director), New Delhi.

2. Shri M.L. Gupta, CMD, THDC.

(A.K. Agnihotri)
Director

ANNEXURE-3

DOCUMENTS/REPORTS PRESENTED IN MEETING ON 5.8.1996

A: Reports prepared by Geological Survey of India :

1. Digital Image Processing of area around Tehri dam site by Shri P.C.Nauani, Shri R.Samuel and Shri H.C. Khanduri (F.S. 1986-89).

2. Geological and tectonic input in seismo-tectonic assessment of Tehri area by Shri P.L.Narula and Shri S.K.Shoma, 1989.

B: Reports prepared by Department of Earthquake Engineering, University of Roorkee:

1. Design Earthquake parameters for Tehri Dam site.
2. Dynamic Soil Parameters for Tehri Dam.
3. Dynamic Soil Parameters and other studies for Tehri Dam (Part-II).
4. Dynamic Analysis of Tehri Dam.

C: Reports prepared by Russian Consultants :

1. Identification of earthquake generating zones in Tehri HPC region.
2. Conclusion of Soviet Consultants on Tehri Dam area, seismicity and recommendations on selecting design ground motions for Tehri Dam.
3. Report on results of seismic micro-zoning of Tehri dam site.
4. Study of stress-strain and analysis of seismic stability of Dam.
5. Dynamic stability analysis for Tehri dam applying accelerogram of Gazli earthquake.

: Miscellaneous :

. Expert Opinions on Tehri Dam Project and Design Aspect of Tehri Dam.

: Reports related to High Level Committee :

. Report of the High Level Committee of Experts constituted to examine all issues relating to Safety Aspects of the Project.

. Comments of the High Level Committee on letter dated 8.5.90 addressed by Prof.James N.Brune of USA to Dr.V.K.Gaur, members of the Committee.

Report on Safety of Tehri Dam by Prof.Jaikrishna.

Expert Group on Tehri Dam (Seismic Safety)

AIDE MEMOIRE

The Group consisting of the following members met to consider the question referred to it concerning the safety of the Tehri Dam :-

Members

1. Prof. N.C. Nigam
2. Prof. V.K. Gaur
3. Prof. R.N. Iyenger
4. Prof. K.N. Khattri
5. Prof. Ramesh Chander

The following were present from THDC side to assist the meeting :-

1. Mr. M.L. Gupta, CMD, THDC
2. Mr. B.L. Jatana, Consultant, THDC
3. Mr. Sumer Singh, THDC
4. Mr. Gopalakrishna, CWC
5. Dr. P.C. Nawani, GSI

2. The base paper on quantification of seismic hazard at Tehri prepared by Prof. K.N. Khattri, was discussed in detail and suggestions made to further refine it.

(Action: Prof. K.N. Khattri)

3. The meeting further desired that the performance of the Tehri Dam be evaluated under the following conditions in order to provide further assessment of the safety of the dam:-

Conditions

(i) Fundamental time period = 1.25 seconds

(ii) Response spectrum
(shape as originally adopted by DEQ, Roorkee University - 10% damping, but anchored at PGA of 0.5 g)

(iii) Elasto-plastic modelling

Note :- The scope of the study will be decided in consultation with DEQ, Roorkee University

(Action : Mr. M.L. Gupta)

4. The Expert Group also had the benefit of detailed presentation by Mr. B.L. Jatana which would be extremely helpful to the group in making comparative assessment of the safety of the dam under different assumptions. It is, therefore, desired that Mr. Jatana may kindly be requested to provide a background note which may include all relevant information concerning the evolving scenario relating to the design of the dam from the very beginning, as well as critical results of its analysis and performance.

(Action : Mr B.L. Jatana)

5. The next meeting of the Committee may be called after the result of analysis under the conditions specified in 3 have been obtained.

(Action : Mr. A.K. Agnihotri)

ANNEXURE-4.2

No. 3 ... 92-D(13N) Hydel II

GOVT. OF INDIA, MINISTRY OF POWER
COMMITTEE ON SIESMIC SAFETY OF TEHRI DAM

AIDE MEMOIRE

Meeting. June 27, 1997

1. BACKGROUND NOTE ON THE TEHRI PROJECT

The Committee received the background report concerning the Tehri project prepared by Shri Jatana and placed on record its appreciation of this important contribution.

2. ACTION ON THE POINTS RECOMMENDED AT THE PREVIOUS MEETING

a) The Committee discussed the final report prepared by Gaur, Khattri and Chander on the estimates of siesmic hazard at the Tehri dam site, using state-of-the-art simulations and based on the basic principles of fault mechanics and seismic wave propagation in the earth.

b) The results of the dynamic response of the Tehri dam to the original response spectrum anchored at 0.5g, as carried out by the Department of Earthquake Engineering was presented by Prof. D.K. Paul. The Committee appreciated the ground thus prepared for dynamic tests of critical structures to prescribed groundmotion histories and desired that a detailed technical report be prepared incorporating the assumptions, methodologies and parameters used.

RECOMMENDATIONS

The Committee desired that the Response Spectrum used for the Tehri site be reviewed in the light of the actually recorded strong groundmotion at Tehri during the 1991 earthquake which showed significant amplification in the relevant frequency band as well as higher value of the magnitude of the earthquake anticipated to rupture the plate boundary in the region, and use this as an input to test the dam response

(Action DEQ UOR)

b) The Committee also desired that in view of the sparsity of actually recorded near source accelograms for great earthquakes (M8 5), dynamic tests of the Tehri dam be also conducted using the simulated acceleration time histories corresponding to a M8 5 earthquake as given in the report (vide 2a above), for

(i) the mean value and
(ii) the mean value + one standard deviation

(Action DEQ UOR)

4. NEXT MEETING

The Committee requested Prof! Nigam, Vice Chancellor, Roorkee University, to kindly use his good offices to get the above mentioned work expedited, whereafter the next meeting be called by the Ministry of Power to finalize the report.

(Action: MIN OF POWER)

Encl. to Aide Memoire dated June 27, 1997

ANNEXURE-4.2A

(O)
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प्रो० नवीन चन्द्र निगम
कुलपति
Prof. NAVIN C. NIGAM
Vice Chancellor

रुड़की विश्वविद्यालय
रुड़की-247 667, भारत
UNIVERSITY OF ROORKEE
Roorkee - 247 667 (INDIA)

No.VC/1780/N

2 August 1997

Dear Prof. Gaur,

This refers to your letter of August 1, 1997 enclosing the Aide Memoire prepared by you on the meeting of the Group on Tehri Dam held on June 27, 1997. The Aidé Memoire does not correctly reflect the substance of the discussions, and recommendations for further action. I would like to suggest that it may be recast as under:

2. ACTION ON THE POINTS RECOMMENDED AT THE PREVIOUS MEETING

a) The Committee discussed the final report prepared by Gaur, Khattri and Chander on the estimates of seismic hazard at the Tehri Dam site using state-of-the-art simulations, and based on the basic principles of fault mechanics and seismic wave propogation in the earth.

It was pointed out by Nigam that the acceleration time history records synthesised in the Report are based on convolution of conservative assumptions at various stages, resulting in an extremely severe ground motions, which cannot be used for engineering analysis and design.

b) The results of the dynamic response of the Tehri dam to the original response spectrum anchored at 0.5g as carried out by the Department of Earthquake Engineering was presented by Prof. D.K. Paul. The Committee appreciated the ground work done for the non-linear dynamic analysis, and the results obtained for the input ground motion decided by the Committee in the last meeting. The Committee desired that a detailed report be prepared highlighting the assumptions, methodologies and parameters used.

3. RECOMMENDATIONS

a) The Committee desired that the Response Spectrum developed by DEQUOR and used for Tehri site, be reviewed in the light of new information obtained from the strong motion records of 1991 Uttarkashi Earthquake. In the procedure adopted by DEQUOR to establish Response Spectrum, the attenuation relations and site effects at Tehri be incorporated based on the recorded data. If the Response Spectrum so obtained is more severe than the Spectrum for which the dam has already been tested under 2(b) above, further testing be done with the new Response Spectrum.

(Action DEQUOR)

b) The Committee also desired that in view of scant empirical data on large magnitude earthquakes at short distances, the dam may also be tested using the simulated acceleration time histories as given in the report (vide 2a above) for the 50th and 84th percentile.

Prof. Khattri will make available the digitised acceleration time history to UORDEQ for the testing. It was noted that the non-linear analysis software used by DEQUOR is based on small deformation theory. If the response to the above ground motion exceeds the limits for which software is valid, such an analysis may not be possible.

(Action : Prof. K.N. Khattri : DEQUOR)

4. NEXT MEETING

Next meeting will be called after the above work is completed.

(Action: MIN OF POWER)

You may amend the Aide Memoire accordingly, or circulate this letter.

With kind regards,

Yours sincerely,

(PROF. N.C. NIGAM)

Prof. V.K. Gaur
Distinguished Professor
Indian Institute of Astrophysics
Koramangala
BANGALORE - 560 034

CONFIDENTIAL

Seismic Safety of Tehri Dam

AIDE MEMOIRE

Meeting on October 9, 1997

The Group of Expert on safety aspects of Tehri Dam met on 09.10.1997 at Room No. 211 in Ministry of Power where following were present :-

Members

1. Prof. N.C. Nigam
2. Prof. V.K. Gaur
3. Prof. K.N. Khattri
4. Prof. Ramesh Chander
5. Prof. RN Iyenger

The following decisions were taken by the Group :-

1. The Group received a report prepared by Prof. DK Paul in respect of the analysis of the Tehri Dam according to the seismic parameters suggested by the Group at its meeting held on 27.01.1997, and considered the results of the analysis. The Group accepted the results of this analysis. The Group observed that the conclusion of the analysis that 'the dam is adequate' was not required and therefore ignored.

2. The effect of the Uttarkashi earthquake on the spectrum of DEQ was re-examined and it was demonstrated that the previous shape was conservative. Hence, it was felt that it was not necessary to repeat the analysis referred to (1) above with a different spectrum

3. The Group reiterated its recommendation that the performance of the dam be tested to an input ground acceleration to be supplied by Prof. Khattri as per report submitted by Gaur *et al*.

4. The comments of the Geological Survey of India (GSI) on the report submitted by Gaur *et al* were tabled at this meeting, as well as report and questions by Gaur *et al* on the choice of the Response Spectrum. These, however, could not be discussed and will be taken at the next meeting. The report of the Tehri Dam Project relating to methods of strain-stress analysis was also produced at the meeting at the request of Prof. Gaur

ANNEXURE-4.4

CONFIDENTIAL

Seismic Safety of Tehri Dam

AIDE MEMOIRE

Meeting on December 21, 1997

The Group of Expert on safety aspects of Tehri Dam met on 21.12.1997 at Room No. 211 in Ministry of Power where following were present :-

Members

1. Prof. N C. Nigam
2. Prof. V K. Gaur
3. Prof. K N. Khattri
4. Prof. Ramesh Chander
5. Prof. RN Iyenger
6. Prof. DK Paul.

The following decisions were taken by the Group :-

1. For the Ground acceleration record generated by Prof. Khattri et al., the non-linear dynamic analysis of the dam could not be carried out as the level of deformation crossed the limit of validity of the software based on small deformation theory.

2. The Committee desired that the actual 3-D profile of the dam for which the dam is to be constructed as well as the value of the material properties be provided to the Committee by the Ministry of Power.

3. Prof. DK Paul was requested to repeat the dynamic analysis for an actual cross-section of the dam for which the core has the maximum height (reference EQ 97-09).

4. For the ground motion generated by Prof. Khattri et.al. representative samples for a N-S horizontal and vertical accelerogram may be selected by him and provided to Prof. DK Paul for a linear dynamic analysis without regard to large deformation to be followed by a slope stability analysis according to the procedure described by T Paskalov.

5. It was agreed that part one of the draft report circulated at the meeting will be finalised through correspondence well before the next meeting.

6. Next meeting is proposed for 31st January, 1998

Minutes of the Meeting held in the office of Prof. N.C. Nigam, Vice Chancellor, Roorkee University on 25.2.1997 regarding the Tehri dam analysis

Following were present

Prof. N.C. Nigam, Vice Chancellor, UOR and Chairman
Prof. R.N. Iyengar, Director, CBRI
Prof. Ramesh Chandra, Professor, ESD
Prof. S. Basu, Professor and Head, DEQ
Prof. D.K. Paul, Professor, DEQ

Sri Sumer Singh, Addl. General Manager (Design) Tehri Hydro Development Corporation Ltd., Rishikesh could not be contacted and therefore he could not attend.

Dr. Nigam welcomed the members and briefed about the discussions in the meeting of the Expert Group held at Delhi and with the Chief Engineer, Tehri dam project. The seismic safety analysis of the Tehri dam was discussed and committee suggested that following studies could be carried out.

1. Generation of ground motion at Tehri site: An artificial ground motion as proposed in DEQ report EQ83-14, with zero period acceleration pagged at 0.5g be generated. Same strength be taken in either horizontal directions. The vertical motion be taken as 2/3 the horizontal motion.

2. 3D Free vibration analysis: 3D free vibration characteristics of the dam will be studied to determine the frequencies of vibration and mode shapes. The material properties (the modulus of elasticity) will be taken to vary with confining pressure. While analysing the dam, the canyon shape, geometry of the dam and material distribution as per latest design will be taken into consideration.

3. 2D linear static analysis: The modulus of elasticity for 2D analysis will be modified in the square of the ratio of the time period obtained by 3D and 2D analysis in order to match the funamental time period of the 2D model of the dam with the 3D fundamental time period. The 2D section will correspond to "Section B" of DEQ Report EQ'89-13.

   The 2D linear gravity turn-on one lift static analysis for gravity loads, water pressures and uplift loads will be carried out using finite element technique to assess the static stresses in the dam. The study will indicate zones of tension or location of likely plastic deformations.

   2D linear dynamic analysis: 2D linear dynamic analysis will be carriedout in order to identify the tension zones or the likely plastic zones at various time intervals for the postulated earthquake.

5. **Dynamic stability analysis:** Dynamic stability of upstream and downstream slopes of the dam will be checked by the pseudo static approach for the specified seismic coefficient at the end of construction. Full reservoir and draw down conditions will also be considered using the modified Bishop's method.

6. **Plastic displacement analysis:** Plastic displacement analysis will be carried out using the concept of yield acceleration for the postulated earthquake.

7. **Nonlinear multi lift static analysis:** 2D plane strain nonlinear stress analysis for gravity, hydrostatic water pressure and uplift pressure to model the construction sequence and the resrvoir filling. In the analysis, the variation of material properties with confining pressure will be taken into account. The nonlinear model of soil will be based on Mohr-Coulomb theory.

   The settlement i.e. vertical and horizontal displacements and contour of ratio of shear stress to ultime shear stress will be determined at the end of construction and reservoir filling.

8. **2D nonlinear dynamic analysis:** The 2D nonlinear dynamic analysis of the dam for the postulated earthquake will be carried out and the maximum dynamic displacement/acceleration at the crest will be worked out. The damping in the first two mode of vibration will be taken as 10%.

   The settlement at some key locations will be worked out for the postulated earthquakes. The permanent crest settlement will be worked out at the end of the earthquake excitations.

Dr. Paul agreed to carry out the above analysis and supply the 3D eigen value analysis results in a one month's time and the whole analysis in three months time. Tehri Hydro Dam Corporation (THDC) will provide the financial support to carry out the above study. The work will be carried out in the sequence indicated above and evaluated at each stage.

The meeting ended with a vote of thanks to the chair.

केन्द्रीय भवन अनुसन्धान संस्थान
रुड़की - 247 667 (भारत)
CENTRAL BUILDING RESEARCH INSTITUTE
ROORKEE - 247 667 (INDIA)

प्रोफेसर रं. ना. अयंगार
निदेशक
Prof. R.N. IYENGAR
Director

No. PA/TD
April 08, 1997

Ref: Your letter No.EQD/Ex.Gp.-Tehri/3555 dated 1.4.1997.

Dear Prof. Basu,

This is to acknowledge receipt of the above letter along with enclosures regarding the meeting held in the office of VC, UOR on 25.2.1997.

My observations on the items mentioned in the minutes enclosed by you are as follows:

(1) The PGA value of 0.5g was discussed and confirmed. The usage of the vertical motion and its strength being 2/3 of the horizontal is not clear to me. I do not remember to have discussed this.

(2) 3-D free vibration analysis: No comments.

(3) 2-D linear static analysis: The alteration of the natural period for purposes of static analysis was not discussed. The change in the modulus of elasticity was for purposes of dynamic studies only. As far as I remember it was mentioned that a 3-D linear static analysis can be easily performed.

(4) 2-D linear dynamic analysis: This is where the matching of the 3-D and 2-D natural period would be needed to find out the zones of weakness and to find out the distribution of the seismic forces along the height of the dam.

(5) Dynamic stability analysis: Even though the Pseudo-static approach would be used in the initial stages, it was mentioned that the seismic coefficients will be computed based on the previous analysis of para No. 4. Hence it is not clear to me what is meant by "Specified Seismic Coefficient". Failure surfaces forming triangular wedges with a horizontal base and the work of Seed and Martin and others were also mentioned in this regard.

I do not have any comments to make at present on para 6, 7 & 8.

The financial support from THDC was not a part of our common discussions.

With regards,

Yours sincerely,

(R.N. Iyengar)

Prof. S. Basu,
Head, Earthquake Engg Department,
University of Roorkee,
ROORKEE

CC: Prof. N.C. Nigam, VC, UOR & Chairman.
Prof. Ramesh Chandra, ESD
Prof. D.K. Paul, DEQ

ANNEXURE-6

QUANTITATIVE ESTIMATE OF SEISMIC HAZARD AT THE TEHRI DAM SITE

by

V.K.GAUR

(SEISMOLOGIST)
DISTINGUISHED PROFESSOR
Indian Institute of Astrophysics
Bangalore

R.CHANDER

(SEISMOLOGIST)
PROFESSOR
University of Roorkee
Roorkee

K.N.KHATTRI

(SEISMOLOGIST)
EMERITUS SCIENTIST
Wadia Institute of Himalayan Geology
Dehradun

(Members - Expert Group)

APRIL 30, 1997

ACKNOWLEDGMENTS

We acknowledge with appreciation the cooperation received from the officials of the Ministry of Power, notably Shri P Abraham, Secretary to the Govt. of India, Shri A K Agnihotri, Director(AH), Shri M L Gupta, CMD, THDC and other distinguished functionaries We thank Dr V.C. Thakur, Director, Wadia Institute of Himalayan Geology for providing institutional support while completing this report Thanks are due to our colleagues in the Expert Group, Professor R N Iyengar, Director CBRI and Professor N C Nigam, Vice Chancellor Roorkee University for their very significant contributions through discussions on the subject of this report Last but not the least we thank Shri V Sriram, Scientist, WIHG for his assistance in the preparation of this report

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EXECUTIVE SUMMARY

Earthquake resistant design of a critical structure is based on an estimate of the most severe ground motion expected at the site during its life time or the equivalent response spectrum. The current design of the Tehri dam, whose natural period will be about 1 25 seconds, rests on the choice of a response spectrum (10% damping) whose spectral accelerations decrease from 0 25 g at 1.0 second period to 0 20 g at 2 second period These accelerations, in turn, correspond to a magnitude 7 0 earthquake whose epicenter is 37 km away from the Tehri dam site

However, according to our current understanding of global tectonics generally, and of Himalayan tectonics in particular, the main threat to the dam at Tehri is posed by a future great Himalayan earthquake of magnitude about 8 5, whose rupture zone lies directly underneath the Tehri dam site at a depth of about 15 km The 84[th] percentile acceleration response spectrum (10 % damping) in respect of such an earthquake, obtained from an ensemble of 21 computer synthesized ground motions, generated specifically for the Tehri dam site, yields spectral vertical accelerations of 0 90g at 1 second and 0 63g at 2 seconds periods. The corresponding north-south accelerations are 1 21g and 0 68g while east-west accelerations are 0.79g and 0.46g respectively. The corresponding values for 5% damping response spectrum are 1.30g (Z), 2.1g (N-S), 1.20g (E-W) at 1 sec period and 0 85g(Z), 0 85g (N-S), 0 55g (E-W) at 2 second period

The above estimates of strong ground motion parameters expected to shake the Tehri dam site have been evaluated for a M 8 5 earthquake using the basic principles of fault mechanics and seismic wave propagation in the earth Recourse to synthetic response spectra is necessary because the main seismic hazard at the site would be from a great earthquake of the Garhwal Himalaya and instrumental observations for such an earthquake do not exist The probability of occurrence of such an earthquake of magnitude $M \geq 8\ 5$ within the next 100 years (counting from 1997) is 0 59

The computation procedure begins by specifying the magnitude of the most probable severe earthquake and the corresponding dimensions of the rupture area, its location and disposition with respect to the site and the amount of slip, as well as the fault type and the local seismic velocity and Q (attenuation of energy figure) structure These quantities are listed in Table 1-ES stating the rationale for their choice, and further clarified in Figure 1 Two extreme influence situations depending on whether the rupture in a great earthquake, which may take over 60 seconds to complete, initiates at A or B, were separately considered to bring out possible variability in the resulting accelerograms

The algorithm and computer program for calculating the accelerograms were adopted from Yu et al (reference 31) The procedure injects randomness in simulations by considering a great earthquake as a concatenation of subevents with circular ruptures of varying sizes that fill the entire prescribed rupture area and have a cumulative seismic moment equal to the total prescribed This procedure has been shown to reproduce the significant features of instrumentally recorded strong ground motion accelerograms at several sites around the world (references 30-38) in the neighborhood of earthquakes of varying magnitudes upto M 8.2, including the Uttarkashi earthquake(reference 31)

Ensembles of 21 visualizations of the fault rupture were considered separately for two extreme situations of the hypocenter (point where rupture is initiated) corresponding to the epicenters at A and B, to generate acceleration time histories at the Tehri dam site The average peak accelerations (cm/s²) and velocities (cm/s) together with standard deviations for the ensembles are as follows

	E-W				Z				N-S			
	a_p	sd	v_p	sd	a_p	sd	v_p	sd	a_p	sd	v_p	sd
Epicenter B	494	98	74	13	908	247	146	30	970	327	151	36
Epicenter A	542	83	88	18	843	322	135	38	778	273	117	16

* standard deviation (sd)

The 5% damping response specra were calculated for all the realizations These are shown in Figure 4 for all the 21 realizations in the case of epicenter being at B together with the mean and mean+sd and mean+2 sd response spectra. Figure 5 shows five realizations when the epicenter is at A. The response spectral values are given in Table 3 The corresponding 10% damping response spectrum for the N-S component (epicenter at B) is shown in Figure 5

According to the current scientific understanding of the rupture mechanism, the case when the epicenter is at B, is considered appropriate for hazard assessment at the Tehri site The mean 5 % damping response spectral values in the period range of 1 to 2 seconds lie between about 1.1g (at 1 second) and 0.45g (at 2 seconds) for the E-W component, about 1 1g and 0 68g for the Z component and 1 6g and 0 66g for the N-S component.

The mean 10 % damping response spectral values (epicenter at B) in the period range of 1 to 2 seconds lie between about 0.68g (at 1 second) and 0.37g (at 2 seconds) for the E-W component, about 0.76g and 0.49g for the Z component and 1.1g and 0.53g for the N-S component.

For a critical structure such as a large dam at Tehri, the 84th percentile estimates of the response spectrum are considered to be an appropriate and sound basis for characterizing earthquake hazard at the site

In order therefore to ensure that the dam when constructed would be able to withstand the strong ground shacking in the wake of a future great earthquake in the Garhwal Himalaya, it would be prudent to dynamically test the performance of its current design according to the expected acceleration responses at the site (given in Tables 5 and 6). A summary of the response values at three periods encompassing the natural period of the Tehri dam are given in the following table.

PERIOD	VERTICAL	HORIZONTAL	
sec	Z	E-W	N-S
5% DAMPING			
1.0	1.30g	1.20g	2.10g
1.25	1.61g	1.10g	1.70g
2.0	0.85g	0.55g	0.85g
10% DAMPING			
1.0	0.90g	0.79g	1.21g
1.25	1.01g	0.76g	1.1g
2.0	0.63g	0.46g	0.68g

Table 1-ES

Earthquake parameters adopted for evaluating seismic hazard due to highly probable severe earthquake the Garhwal Himalaya during the life-time of Tehri dam.

S No	Parameter	Adopted value	Based on
1	Magnitude	8 5	The smooth curvature of the Himalaya arc from Kashmir to Assam formed by succession of stick-slip underthrusting c the Indian plate requires a uniform sty of deformation along the entire arc for Kashmir to Assam The rate of strain accumulation in th Central Himalaya caused by the persister northward drive of the Indian Plate is 1 to 20 mm/year, which piles up atleast 15 cm of strain every year Apart from moderat earthquakes such as 1991 Uttarkash event which release only a small portio of the accumulated strain, no grea earthquake (M 8+) have been known to occur in the Central Himalaya for atleast 500 years The current strain budget in this regior must therefore be between 7 to 10 meters Assuming the uniform style of deformation along the Himalayan arc and the strain release by the great earthquakes as witnessed in the past 100 years, a strain budget of 7 meters would be capable of producing a magnitude 8 5 earthquake in the region. For example a 7 meter slip on a 300 km long 100 km wide rupture will produce an earthquake of magnitude 8 5. This figure also matches the average of the magnitudes of the past 4 great earthquakes each of which ruptured about 300 km long segment of the Himalayan arc.
2	Seismic moment	6 0x10^{28} dyne-cm	Observations of convergent plate boundary earthquakes, especially the great Himalayan earthquakes

3	Static stress drop	6.2MPa (62 bars)	-do-
4	Sub-event stress drop	10mpa (100 bars)	High stress regime in the Himalaya (References 45,46)
5	Fault type	Thrust fault	Geological evidences of plate convergence, fault plane solutions of moderate Himalayan earthquakes, size of meizoseismal zones of past great earthquakes of the Himalaya. Evidence for plate convergence
6	Fault plane dip and its shortest distance from the dam site	6° due NE 15 km	All known geological indications and earthquake mechanism solutions of moderate earthquakes point to a detachment plane in the region. The rupture zones of the past 4 great earthquakes, are also found to be consistent with a gently dipping detachment zone underneath the lesser Himalayas. This detachment plane has recently been mapped on the Nepal Himalaya by French scientists Dip amount is the same as for the plate boundary fault inferred by Ni and Barazangi (1984) from spatial distribution of 28 hypocentres whose focal depths have been revised. Dip direction sub-parallel to that of MCT and many other major thrusts of the Garhwal Himalaya Shortest distance from Tehri geometrically calculated
7	Rupture dimensions	240 km along fault strike 80 km along fault dip	Analyses of Khattri, Seeber and Armbruster, Molnar and Pandey, Chander and Gahalaut for great earthquakes of 1897, 1905 1934 and 1950
8	Rupture location relative to Tehri	See Fig 1	The existence of seismic gap in the Garhwal Himalaya
9	Hypocentral location	In the plate boundary fault near deeper long edge of rupture	Experience worldwide for great earthquakes at convergent plate margin.
10	Hypocentral depth	18 km	-do- Also estimates of Seeber and Armbruster,

			Molnar and Pandey
11	Epicentral locations		Two end member locations shown by points A and B in Fig.1
12	Rupture propagation		Away from hypocentre. 21 randomly chosen scenarios for epicemter at B and five for epicenter at A
13	Probability of occurrence of Great earthquake in the next 100 years	Estimated probability of recurrence = 0.59 Average slip rate -2cm/a Average return period - 300 years Time relapsed since last earthquake 500 years.	Average slip rate, Slip in Great earthquakes, return period, relapsed time since last great earthquake, Log-normal distribution of recurrence time. (References 49,50,51)
14	Velocity and Q models	Table given below	Determined from seismological data and modeling of the 1991 Uttarkashi earthquake accelerograms (Reference- 31)

The parameters of the medium between Tehri and the hypocentre

Depth from the surface (km)	Thickness (km)	V_p (km/s)	Q_p	V_s (km/s)	Q_s	Density (gm/cc)
0.00 - 0.05	0.05	0.90	10	0.50	5	1.80
0.05 - 0.55	0.50	1.75	30	1.00	15	1.80
0.55 - 2.55	2.00	4.90	100	2.80	50	2.40
2.55 - 16.55	14.0	5.20	4000	2.97	2000	2.60
16.55 - 46.55	30.0	6.00	4000	3.43	2000	2.90
> 46.55	Half-space	8.33	1000	4.83	500	3.30

1 RATIONALE FOR CHOICE OF MODELS FOR SEISMIC HAZARD ANALYSIS FOR TEHRI DAM SITE AND RESULTS

1) PROBABILISTIC HAZARD ESTIMATION

A probabilistic hazard analysis of the Himalayan region based on the principles enunciated in appendix II indicates that for an exposure period of 50 years the peak ground accelerations (a_p) of over 0 7 g will be exceeded with a rate of 1 in 10 (ref 3) The value of a_p will scale to about 0 9 g for a 100 year exposure period, which corresponds to the life time of the Tehri dam[4] The dam site is situated in a zone corresponding to which the above estimate applies An estimation of the peak ground acceleration acquires significance as it is used to anchor fixed shape response spectrum (FSRS)

2) THE ESTIMATION OF THE MOST DAMAGING EARTHQUAKE IN THE TEHRI REGION WITHIN THE NEXT ABOUT 100 YEARS

The estimation of seismic hazard in a region depends upon the most damaging earthquake that can occur in the region in the time window under consideration. This is illustrated by considering the accelerations expected for large earthquakes For example, the Idriss[5] formula provides the following estimates for acceleration values for the cases of M 8 and M 8.5 earthquakes at distances of 15 and 25 km

Table 1. Acceleration values using Idriss formula[5] (quoted from Liam-Finn[6])

	M=8		M=8.5	
	R=15km	R=25km	R=15km	R=25km
ap	0.66g	0.485g	0.75g	0.575g
asp at T= 0.3s	2.1g	1.6g	2.5g	2.0g
asp at T= 2.0s	0.44g	0.31g	0.57g	0.41g

The above table shows two things First, there is a drastic increase in expected acceleration amplitudes as we go from M8 to M8.5 Secondly, the high values of the spectral accelerations imply a long duration of shaking with high acceleration values

According to Campbell[7] peak ground acceleration of 0 9 g (at 84th percentile level) is predicted at a distance of 15 km for a M =8 earthquake at sites with low velocity soil cover (as is the case at the Tehri site) This value should be higher for a M = 8 5 earthquake

SEISMOTECTONIC CONSIDERATIONS

The Himalaya are the locale of very active tectonics[8,9] The Earthquake belt in the Himalaya is witness to the process of strain accumulation, and it's catastrophic release in the form of earthquakes The region has experienced four great earthquakes in the past about 100 years, namely, the 1897 Assam(M8 7+), 1905 Kangra(M8 6), the 1934 Bihar-Nepal(M8 4), and 1950 Assam(M8 7) The occurrence of peak accelerations in excess of 1 g in the great 1897 Assam earthquake has been well documented[10] Since the geological process of the collision of the Indian plate with the Eurasian plate continues, causing the of accumulation of strain, occurrence of such great earthquakes in the Himalaya in the future is a certainty. The published leveling data along the Saharanpur-Dehradun-Mussoorie highway when interpreted suitably show all the evidence for the operation of an earthquake cycle and the accumulation of strain for the next great earthquake in the region[11]

4) AVERAGE RETURN PERIOD OF GREAT EARTHQUAKES

An appraisal of the average return period of the M8+ earthquake in the region is, therefore pertinent to the problem of seismic hazard estimation. This can be based on the strain budget of the region. The frequency of great earthquakes is constrained by the rate of strain accumulation in the region. The rate of strain accumulation has been estimated using a variety of techniques. The average rate of plate convergence obtained from marine magnetic anomalies is 5cm/a[11]. However, a fraction of this is released in the region north of the Himalaya. Thus, it sets an upper limit of the rate of strain in the region. Using the deformation of the upper Tertiary sediments in the Ganga foredeep, the average rate of strain is estimated to be 1.0 to 3 cm/a in the western parts of Himalaya[12,13]. In the U.P. part of the Ganga foredeep, the average rate of convergence is estimated to be 1.8 ±0.4 cm/a[14] from the velocity of the southward onlapping of the Indian shield. The elastically stored component of the average rate of convergence has been estimated using the rate of seismic moment released in great earthquakes in Himalaya. It is 1.7±0.3 cm/a[15]. This strain becomes available for causing future earthquakes in the region. Using the fractal description of earthquakes together with the complete catalog of earthquakes, the average rate of slip over the basement thrust in Himalaya has been estimated to be 3.5 cm/a[16]. This rate will be approximately equal to the average rate of convergence in the Himalaya. Geodetic measurements using leveling in Dehradun and in Kathmandu areas, have been analyzed to provide an estimate of the average rate of elastic strain accumulation of 0.7 cm/a in the outer Himalaya region[17]. The GPS measurements in Nepal led to an estimate of convergence rate of 1± 1cm/a[18]. An application of the Savage model of earthquake recurrence at convergent plate margins reveals that the Nepalese leveling observations are consistent with a plate convergence rate of 18 mm/a in the Himalaya[20].

From the foregoing it emerges that the average rate of convergence in the Himalaya lies in the range of 1 to 3 cm/a. The rate may vary along different sections of the Himalaya. This can be revealed by detailed investigations using modern techniques like the GPS.

One may take the average rate of elastically stored convergence to be 2 cm/a. Then sufficient strain will become available in any sector of Himalaya to generate a great earthquake in a period of about 500 years. In the sector in front of the Salt range, where the rate has been estimated to be 1cm/a, the average return period will be correspondingly longer. In the sector containing the Pir Panjal Range where the rate of convergence is estimated to be 3cm/a year, the average return period is anticipated to be shorter. In the central gap region the estimated rate of convergence is close to the average value, therefore, the 500 year return period is representative.

5) PROBABLE OCCURRENCE OF A GREAT EARTHQUAKE IN TEHRI REGION

The past great earthquakes in the Himalaya have relieved the accumulated strain in about 35% of the Himalaya plate boundary. The remaining sections of the Himalaya plate boundary have not experienced a great earthquake for the past at least 300 years, possibly 500 years or more. Thus, these sections, called seismic gaps, have accumulated a large amount of strain, and are places of high seismic potential for a future great earthquake in the next 100 to 300 years or so. The Tehri dam site lies in one such gap(Central gap)[19,20], for which the shorter time interval of 100 years is pertinent.

6) THE PROBABILITY OF RECURRENCE OF THE GREAT EARTHQUAKE

The probability of recurrence of the great earthquake in the Tehri region in the time window 1997-2097(100 years) has been calculated from a density probability function for the random time of recurrence, T. The lognormal distribution is used[10]. The conditional probability for the case of the earthquake having not occurred prior to T_e is given by

$$P(T_e \leq T \leq T_e + dt \mid T > T_e) = P(T_e \leq T \leq T_e + dt) / (1 - P(0 \leq T \leq T_e))$$

where Te is the elapsed time since the last great earthquake in the region. The values of the parameters used in the calculation are 500 years before 1997 for T_e, the average repeat time of 500 years, the average slip rate of 2cm/a and parametric uncertainty, σ_p of 0.4. The probability for the recurrence of the great earthquake is 0.59

7) ESTIMATION OF STRONG GROUND MOTION TIME HISTORIES AND CORRESPONDING RESPONSE SPECTRA

In the present analysis we use the composite source model that takes into account the random nature of the complex source slip function which together with the use of synthetic (theoretical) Green's functions enables to simulate realistic accelerograms of a potential Mw 8.5 earthquake in the Tehri region[29-31].

The above method has been found to be quite successful in Modeling strong ground motion time histories (accelerograms) for the case of a number of earthquakes in a wide range of magnitudes(up to 8.2) from Himalaya, Mexico and U.S.A[30-33]

The Source Model

On account of the heterogeneities in the rocks due to composition and geometrical structures the rupture in a faulting process is highly irregular. We model the rupture phenomena by a large number of randomly distributed sub-events over the fault plane of the main earthquake. The rupture is started at the nucleation point and propagates at constant velocity to cover the entire area of the main fault. As the rupture front touches the center of a particular subevent, it radiates a source pulse given by Brune pulse[38] having amplitude in accordance with the seismic moment of the sub-event. The composite source time function is obtained by an appropriate sum of the sub-event source time functions[31-40]. The complete Green's functions are synthesised for a plane layered earth model using wave number integration method[40]. The convolution of the source time function with the Green's function gives the ground motion time history at a site. This methodology need not necessarily represent actual physical characteristics at particular points of the rupture but rather a method to parameterize the inherent complexities in fault rupture and wave propagation.

We define the velocity-Q structure in the region on the basis of earlier investigations of microearthquakes in the region[41] and the successful modeling of the strong motion recordings of the 1991 Uttarkashi earthquake[31,32]. This is given in the Table 2

Table 2. Velocity Model for Tehri dam site

Thickness	VP	QP	VS	QS	Density
km	km/s		km/s		gm/cc
0.05	0.90	10	0.50	5	1.80
0.5	1.75	30	1.00	15	1.80
2.0	4.90	100	2.80	50	2.40
14.0	5.20	4000	2.97	2000	2.60
30.0	6.00	4000	3.43	2000	2.90
1000.0	8.33	1000	4.83	500	3.30

This model has taken into consideration the local site effects prevalent at the Tehri dam site

A hypothesis has been made that the value of Q will be very low, of the order of 50 for shear waves in the upper crust However, modeling of the strong motions at Tehri for the Uttarkashi earthquake produced considerable mismatches of the observed and the synthetic accelerograms and their spectra[11] On the other hand the values adopted here (Table 2) have provided good matches Further, several studies have demonstrated that Q is very high in seismogenic zones[12-44].

The earthquake magnitude is selected on the basis of the average of the magnitudes of the great earthquakes of Himalaya and the value is M_w 8.5 The corresponding moment Mo is 6e28 dyne -cm A fault dimension of 240 by 80 km is chosen which is consistent with the magnitude of the hypothetical event. The fault plane lies between the MCT in the north and the MBT in the south. The fault plane is dipping to the NE at an angle of 60° and its northern (deeper) edge is at a depth of 18 km. The static stress drop of the earthquake is 62 bars However, stress drops of 275 bars and 537 bars have been estimated for the 1934 great Bihar and the 1935 Quetta earthquakes[47]. For the 1991 Uttarkashi earthquake (M_s 7) a stress drop of about 50 bars has been estimated[44]. The choice of subevent stress drop is governed by the knowledge that the Himalaya are a region of very high stress[43,44]. Thus a sub-event stress drop of 100 bars is selected for the simulations.

The surface projection of the fault for the hypothetical earthquake is shown in Figure 1 along with the location of Tehri site and the surface traces of the Main Central Thrust(MCT) and the Main Boundary Thrust (MBT)

A number of realizations of the fault rupture were calculated in order to visualize the possible variations of the resulting strong ground motions and obtain a statistical measure for the same. Two alternative positions, A and B for the start of rupture were considered to investigate the effect of the focusing due to the rupture propagation. A few ensembles of the strong motion realizations for each are shown in Figures 2 and 3 respectively The energy build up in the in the case of rupture point at B occurs in the very beginning whereas in the case of rupture point at A the strongest pulses arrive at a later time Another significant difference is that while in the case of B the E-W component records significantly (about 50%) lower peak values than in the N-S component, the energy levels in the case of A are similar in both the horizontal components

The average peak accelerations (cm/s^2) and velocities (cm/s) together with standard deviations (sd) for the ensembles are as follows

	E-W				Z				N-S			
	a_p	sd	v_p	sd	a_p	sd	v_p	sd	a_p	sd	v_p	sd
Epicenter B	494	98	74	13	908	247	146	30	970	327	151	36
Epicenter A	542	83	88	18	843	322	135	38	778	273	117	16

The 5% damping response spectra were calculated for all the realizations. These are shown in Figure 4 for all the 21 realizations for the case of epicenter at B together with the mean and mean+sigma and mean + two sigma response spectra The response spectral values are give in Table 4 Figure 5 shows the same for the five realizations for epicenter at A.

The response spectrum (10% damping) currently adopted for the design of the Tehri dam is shown in Figure 6 An anchoring PGA value of 0 25g has been used to obtain this response spectrum. The spectral responses in the 1 to 2 s range is about 0.25 g to 0.2 g.

The response spectrum for 10% damping for the simulations (N-S component) for rupture point corresponding to the epicenter at B are shown in Figure 7. The currently adopted response spectrum (shown in Figure 6) is also shown here in dotted lines for comparison. Three other response spectra obtained from the currently adopted spectrum by scaling up respectively by factors of 2, 3, and 4 are also shown in the same figure. The scaling correspond to anchoring the response spectrum with the PGA values of 0.5g, 0.75g and 1.0g respectively.

According to the current scientific understanding of the rupture mechanics, the choice of epicenter at B is considered appropriate for hazard assessment at the Tehri site. The mean response spectral values for epicenter at B (5% damping) in the period range of 1 to 2 seconds range between about 1.1 g (at 1s) to 0 45 g (at 2 s) for the E-W component, about 1.1 g and 0.68 g for the Z component and 1.6 g and 0.66 g for the N-S component.

At 84% level these figures are respectively (1.2 g;0.55 g) for the E-W component, (1.3 g ; 0.85 g) for the Z component and (2.1 g ; 0.85 g) for the N-S component (Figure 4 and Table 3).

The mean response spectral values for epicenter at B (10% damping) in the period range of 1 to 2 seconds lie between about 0.68 g (at 1s) and 0 37 g (at 2 s) for the E-W component, about 0 76 g and 0.49 g for the Z component and 1.1 g and 0 53 g for the N-S component.

At 84th percentile level these figures are respectively (0 79 g ; 0.46 g) for the E-W component, ([illegible] g ; 0 6[illegible] g) for the Z component and (1 21 g , 0 58 g) for the N-S component (Figure 7 and Tables 5 and 6)

For critical structure such as a large dam at Tehri, the 84th percentile response spectral values shown in Figures 4 and 7 and given in Tables 3 and 6 are regarded as realistic estimates of the strong ground motion parameters at the Tehri dam site for a probable M8.5 earthquake.

In order therefore to ensure that the dam when constructed would be able to withstand the strong ground shacking in the wake of a future great earthquake in the Garhwal Himalaya, it would be prudent to dynamically test the performance of its current design according to the expected acceleration responses at the site (given in Tables 3 and 6).

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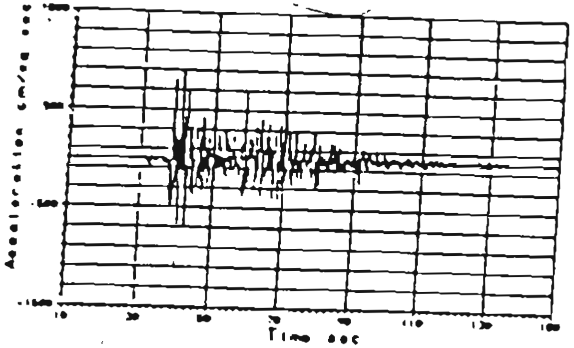
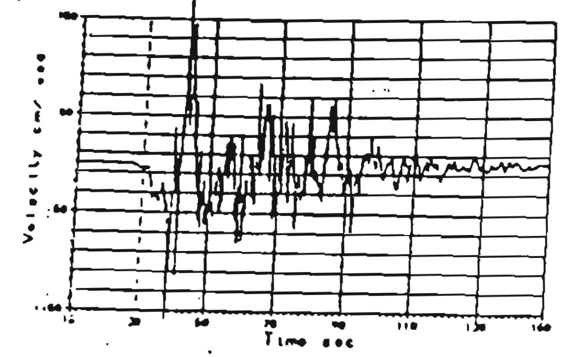
Figure 2. Three sample accelerogram realizations at Tehri out of an ensemble of 21 for epicenter at B.

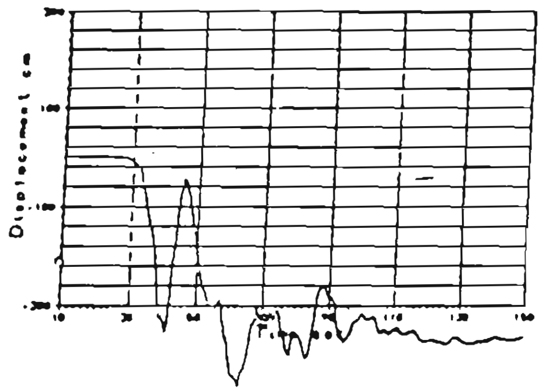
TEHRI N-S HYPOTHETICAL M=8.5 1008 B=5



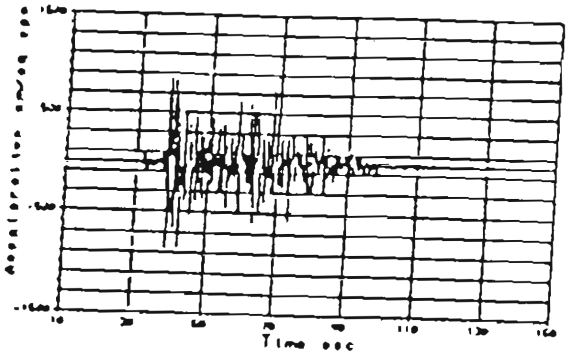
TEHRI N-S HYPOTHETICAL M=8.5 1008 B=5



TEHRI N-S HYPOTHETICAL M=8.5 1008 B=5



TEHRI U-D HYPOTHETICAL M=8.5 1008 B=5



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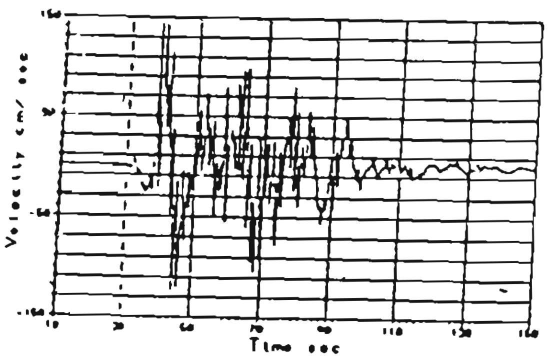

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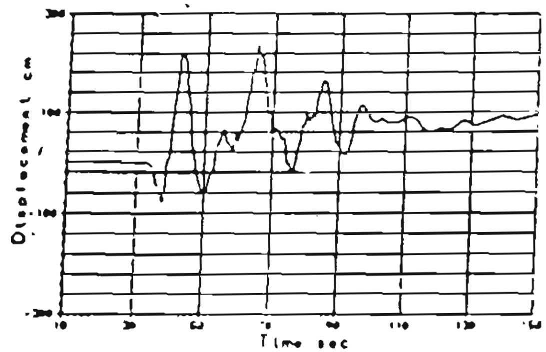

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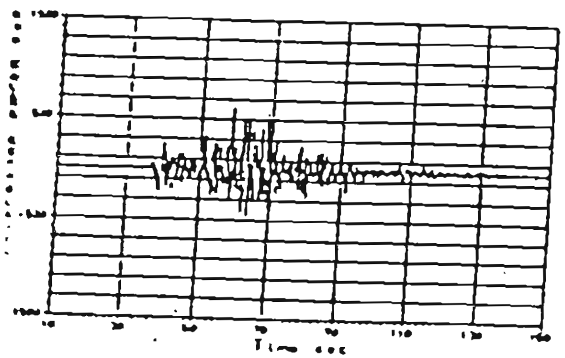

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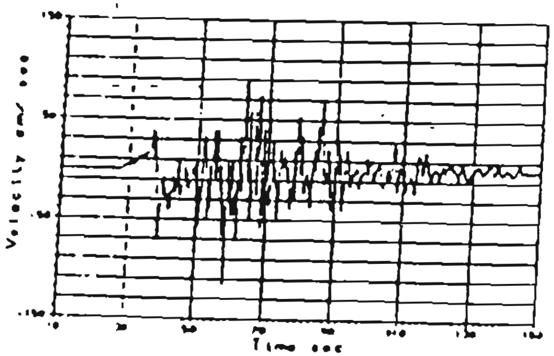
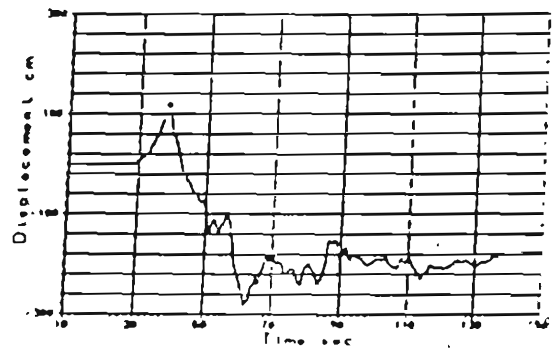
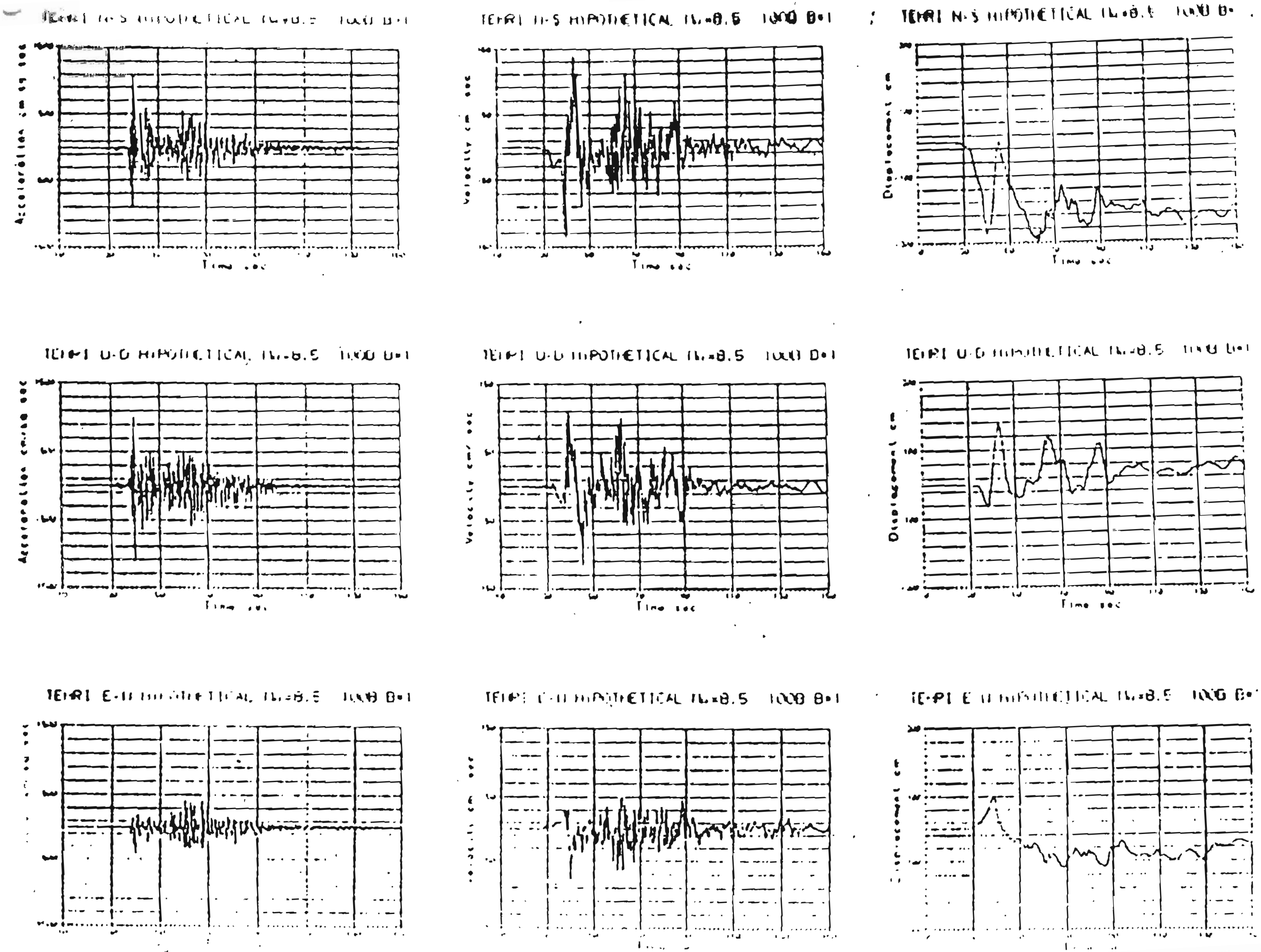


TEHRI E-W HYPOTHETICAL M=8.5 1008 E=5




TEHRI N-S HYPOTHETICAL M=8.5 1000 B=1
Acceleration cm/sq sec
Time sec
Velocity cm/sec
Displacement cm
TEHRI U-D HYPOTHETICAL M=8.5 1000 B=1
TEHRI E-W HYPOTHETICAL M=8.5 1000 B=1

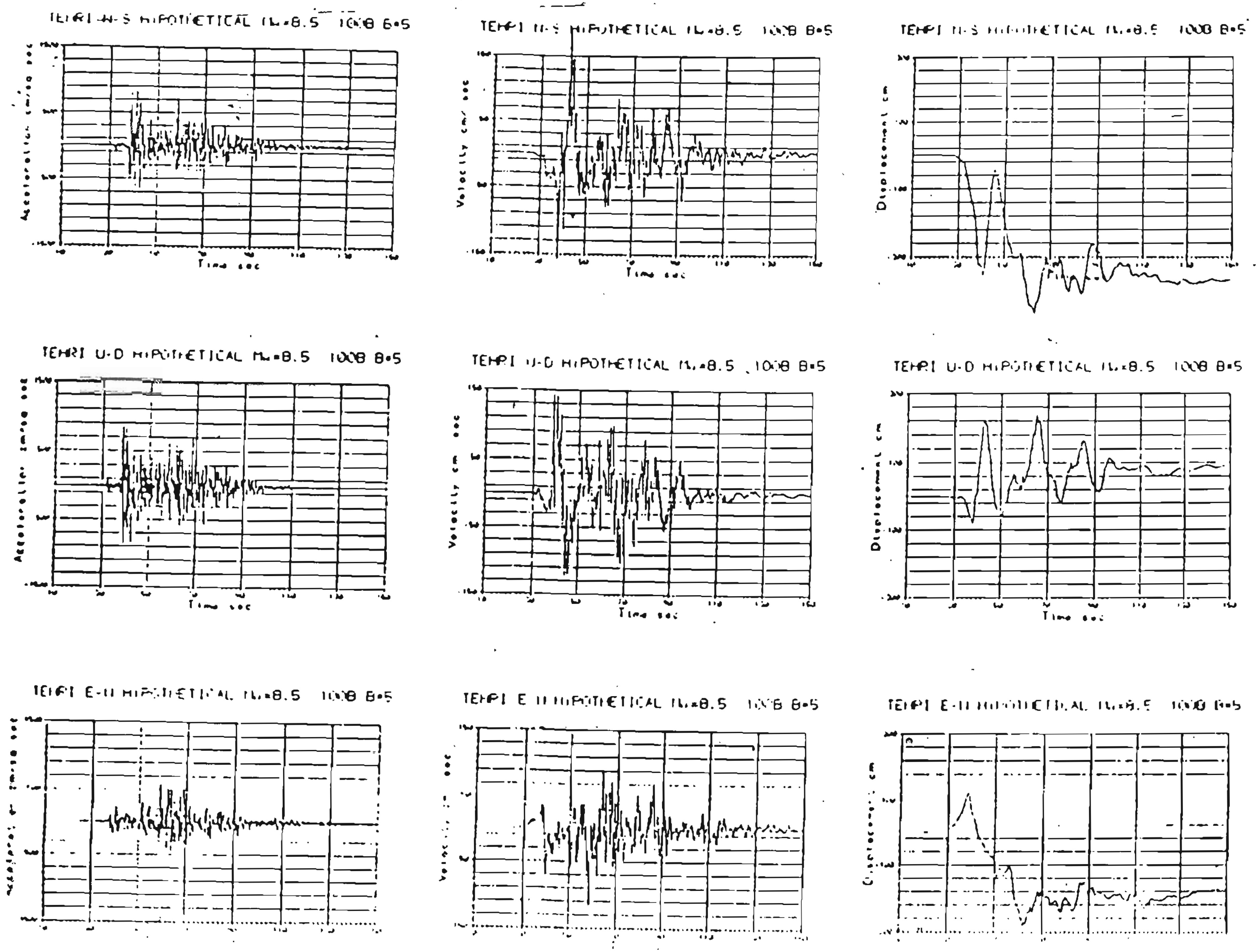

TEHRI N-S HIPOTHETICAL M=8.5 1008 B=5
Acceleration cm/sec sec
Time sec
TEHRI N-S HIPOTHETICAL M=8.5 1008 B=5
Velocity cm/ sec
Time sec
TEHRI N-S HIPOTHETICAL M=8.5 1008 B=5
Displacement cm
TEHRI U-D HIPOTHETICAL M=8.5 1008 B=5
Acceleration cm/sec sec
Time sec
TEHRI U-D HIPOTHETICAL M=8.5 1008 B=5
Velocity cm sec
Time sec
TEHRI U-D HIPOTHETICAL M=8.5 1008 B=5
Displacement cm
Time sec
TEHRI E-W HIPOTHETICAL M=8.5 1008 B=5
TEHRI E-W HIPOTHETICAL M=8.5 1008 B=5
TEHRI E-W HIPOTHETICAL M=8.5 1008 B=5

Figure 3. Three sample realizations of accelerograms at Tehri for epicenter at A.

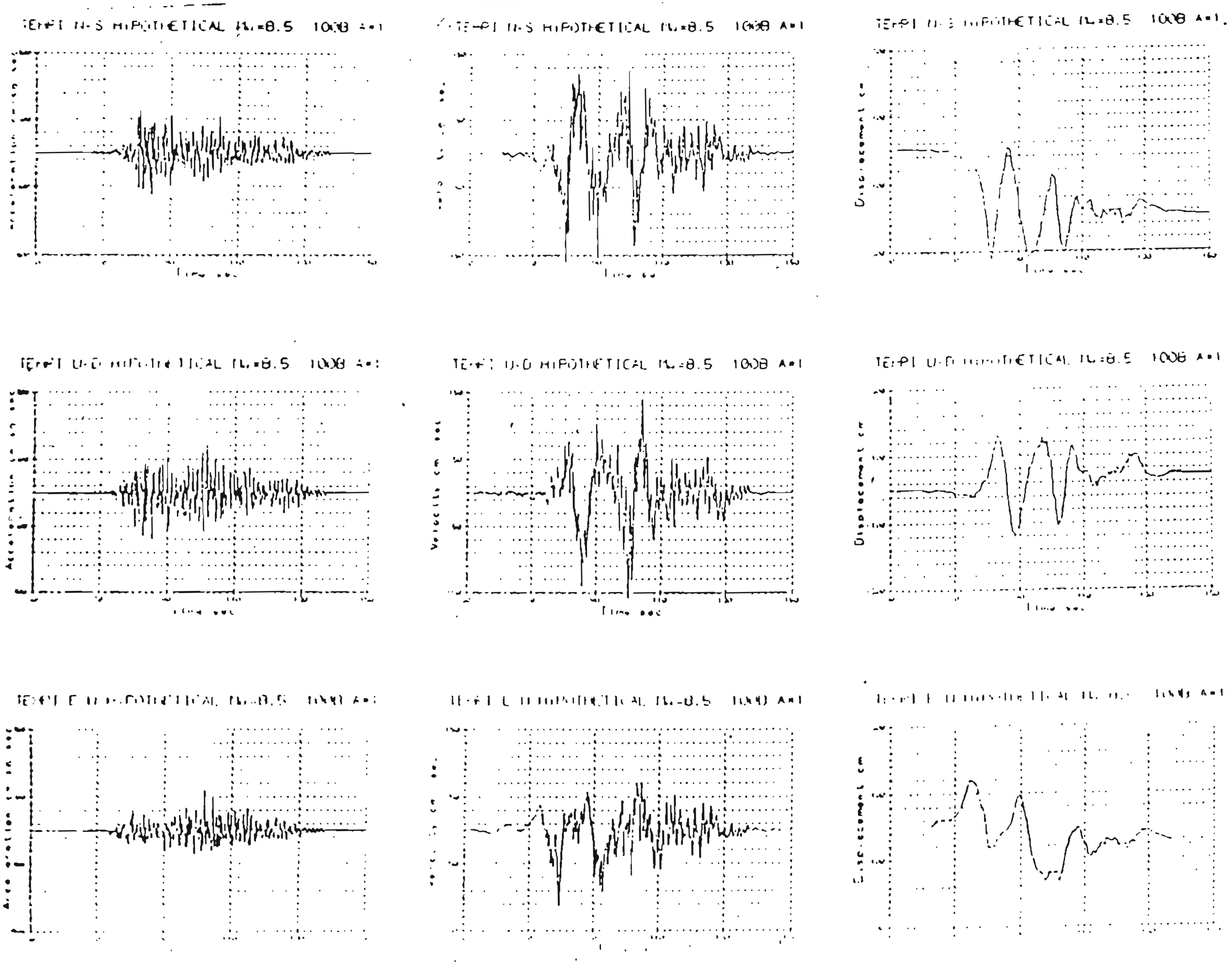

TEHRI N-S HIPOTHETICAL
TEHRI U-D HIPOTHETICAL
Time sec
Displacement cm
Velocity cm sec
Acceleration

Figure 4 Response Spectra at Tehri of all 21 realizations for epicenter at B The mean and mean−sd and mean + 2 sd response spectra are also shown.

RESPONSE SPECTRA - 5 % DAMPING

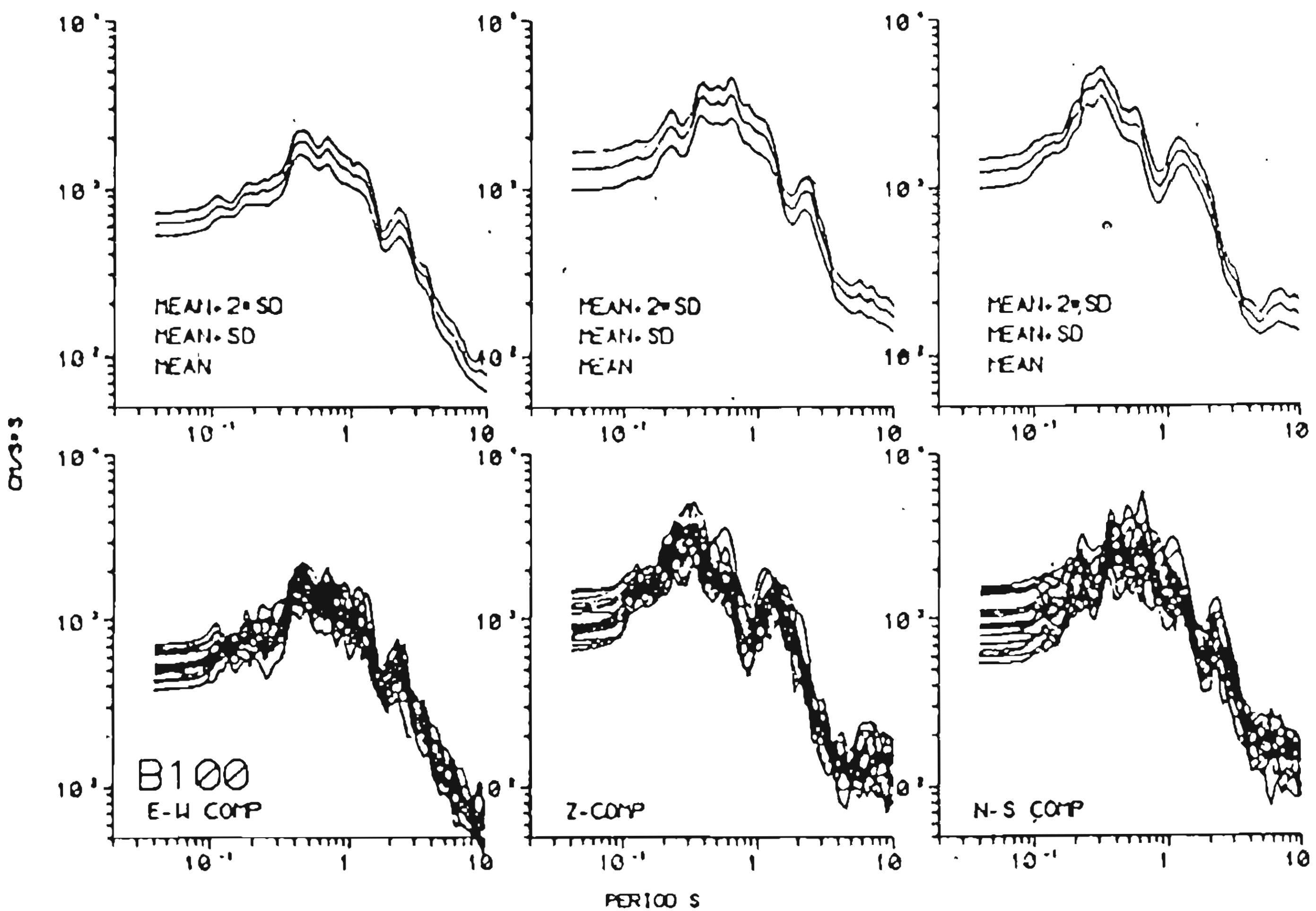


Figure 5. Response Spectra at Tehri of all 5 realizations for epicenter at A. The mean and mean+sd and mean + 2 sd response spectra are also shown.

RESPONSE SPECTRA - 5 % DAMPING

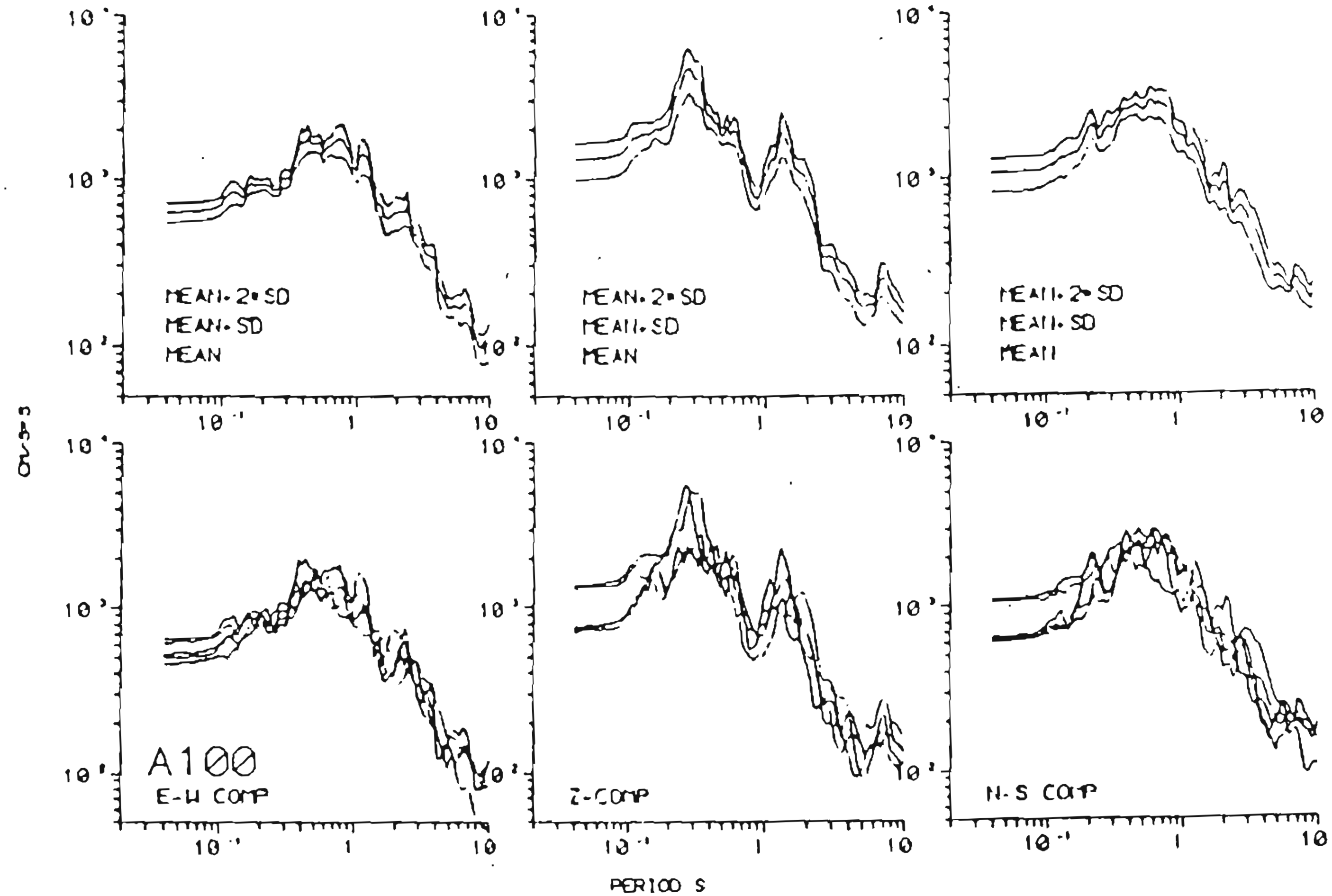
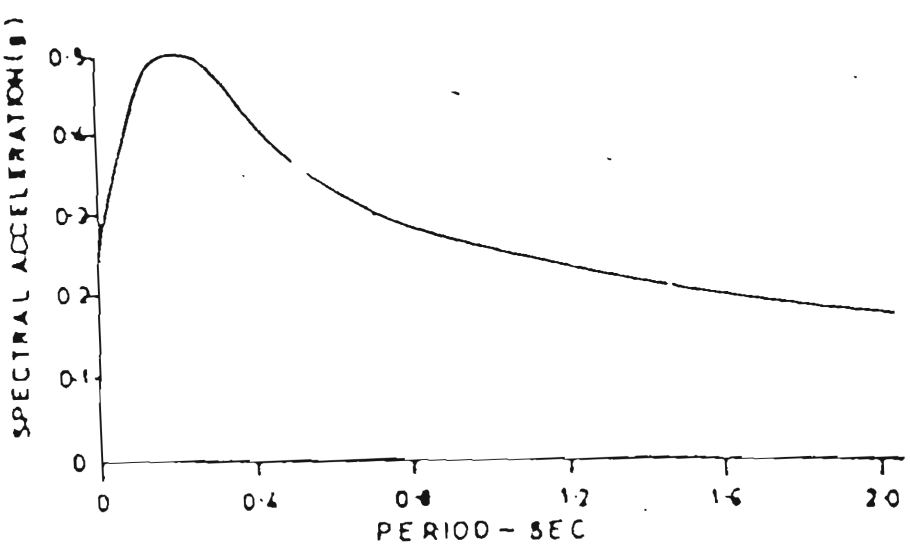


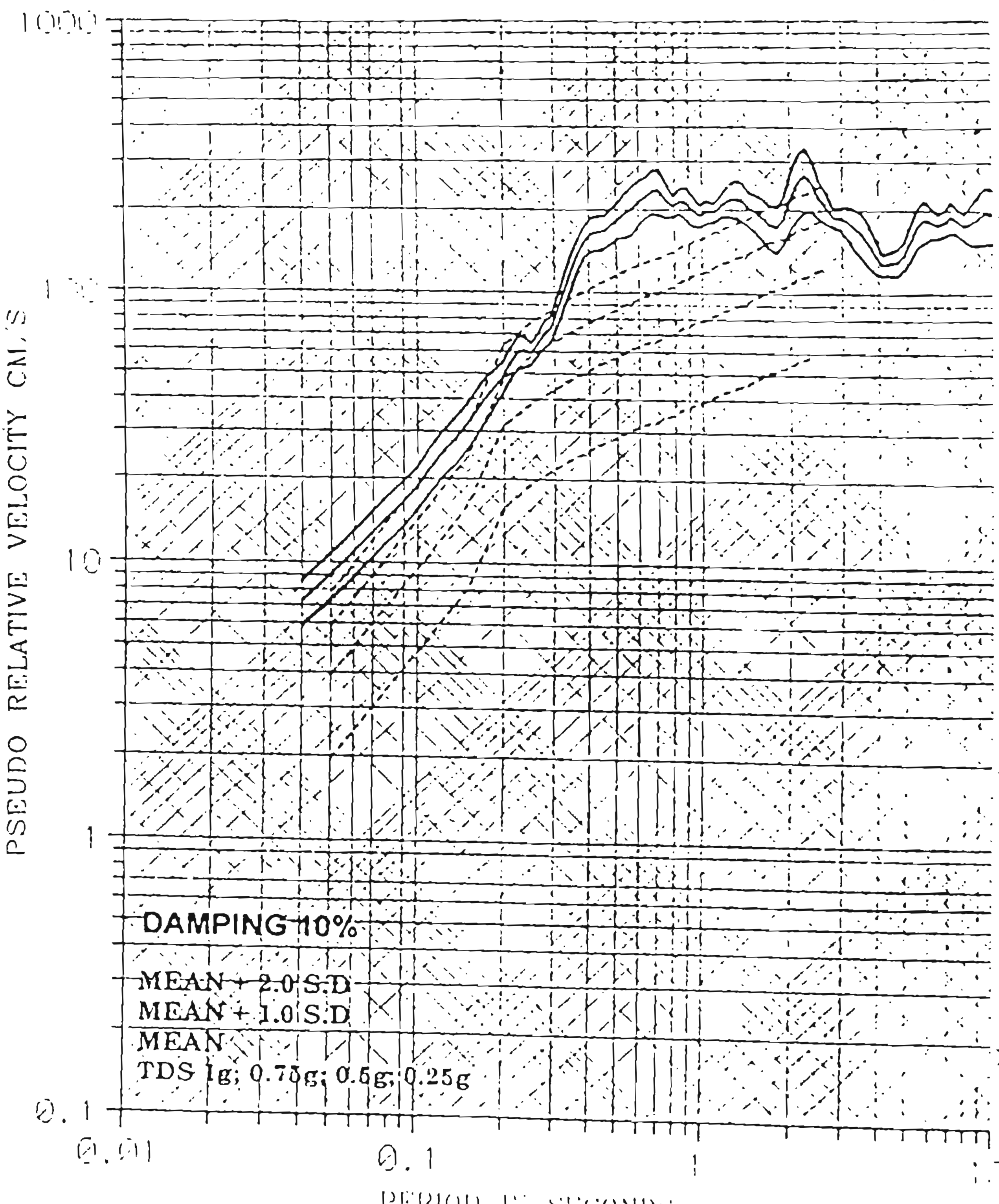
Figure 6. Response spectrum adopted for Tehri dam

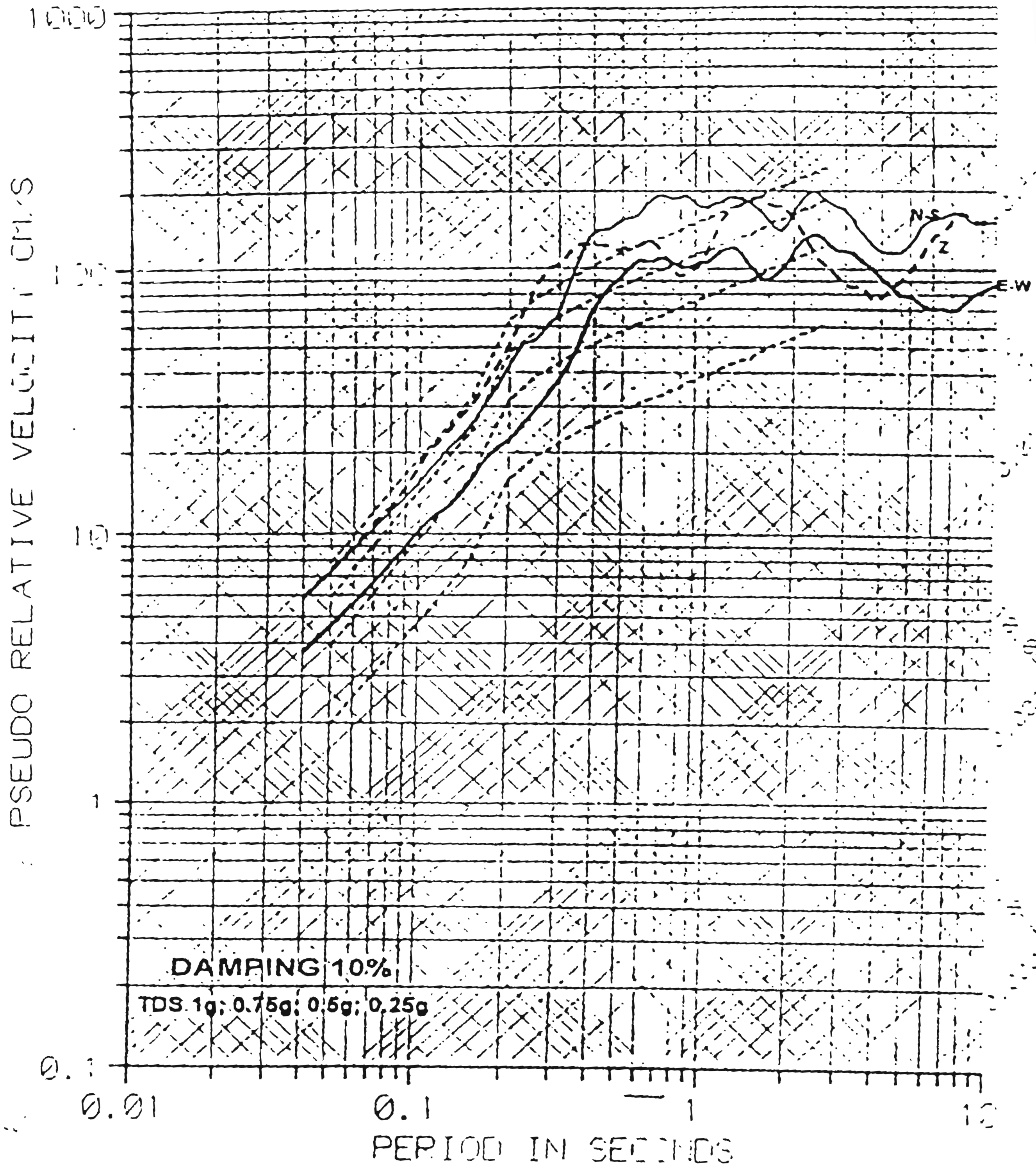


ACCELERATION RESPONSE SPECTRA FOR TEHRI DAM

Figure 7 A) The 10% damping response spectra at Tehn for epicenter at B for N-S component.
The continuous lines show the mean, mean plus one standard deviation and mean plus two standard deviation response curves for simulations for Tehn. The dotted lines show the currently adopted response spectrum (lowest curve) and three versions derived from above by scaling by factors of 2, 3 and 4

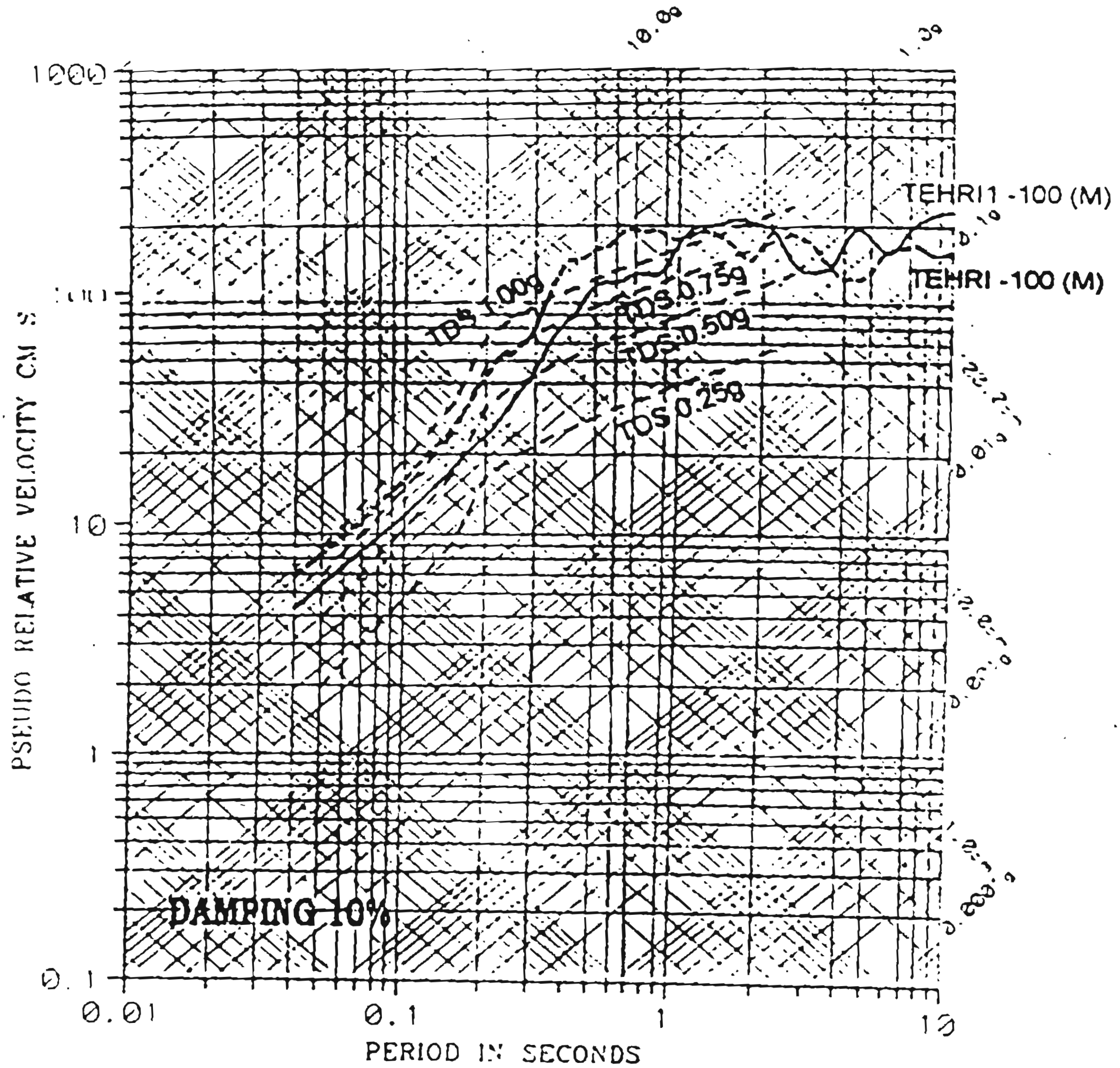
B) The mean response specra (10%damping) for all the components.


1000
100
10
1
0.1
PSEUDO RELATIVE VELOCITY CM/S
DAMPING 10%
MEAN + 2.0 S.D
MEAN + 1.0 S.D
MEAN
TDS 1g; 0.75g; 0.5g; 0.25g
0.01
0.1
1
PERIOD IN SECONDS



PSEUDO RELATIVE VELOCITY CM/S
1000
100
10
1
0.1
0.01
0.1
1
10
PERIOD IN SECONDS
N-S
Z
E-W
DAMPING 10%
TDS 1g; 0.75g; 0.5g; 0.25g

Figure 8 The 10% damping response spectra at Tehri for epicenter at B. The continuous line shows the mean curve for simulations for Tehri with modified velocity model. The thick dotted line shows the mean response for the original velocity model. The dotted lines show the currently adopted response spectrum (lowest curve) and three versions derived from above by scaling by factors of 2, 3 and 4.



TEHRI1 -100 (M)
TEHRI -100 (M)
TDS 1.00g
TDS 0.75g
TDS 0.50g
TDS 0.25g
DAMPING 10%
PSEUDO RELATIVE VELOCITY CM/S
PERIOD IN SECONDS
1000
100
10
1
0.1
0.01
0.1
1
10

Table 3 Response Spectra values at Tehri for epicenter at B

RESPONSE SPECTRA - 5 % DAMPING (CM/S*S)
E-W COMPONENT

PERIOD(S)	M	M+SD	M+2SD	SD
.04000	519	616	713	97
.04227	520	617	714	97
.04467	521	618	716	98
.04721	522	619	716	97
.04989	523	619	716	97
.05272	524	621	718	97
.05571	525	623	720	97
.05887	527	625	723	98
.06222	529	627	726	98
.06575	532	631	730	99
.06948	536	636	735	100
.07342	541	641	742	101
.07759	546	648	750	102
.08200	553	656	759	103
.08665	563	667	771	104
.09157	577	683	789	106
.09677	600	711	822	111
.10226	630	750	869	119
.10807	658	779	901	121
.11420	676	777	878	101
.12068	670	756	842	86
.12753	677	752	827	75
.13477	674	743	811	68
.14243	666	746	825	80
.15051	697	797	898	100
.15905	742	861	980	119
.16808	795	925	1056	130
.17762	787	932	1077	145
.18771	790	941	1092	151
.19836	793	928	1062	135
.20962	800	936	1071	135
.22152	802	960	1118	158
.23410	787	963	1139	175
.24739	780	948	1115	168
.26143	811	983	1155	172
.27627	840	1022	1204	182
.29196	867	1041	1214	173
.30853	915	1090	1264	175
.32604	1010	1191	1373	182
.34455	1157	1361	1565	204
.36411	1352	1590	1828	238
.38478	1491	1767	2043	276
.40663	1565	1871	2176	306
.42971	1561	1889	2216	328
.45410	1555	1871	2186	316
.47986	1515	1803	2092	288
.50712	1420	1693	1966	273
.53591	1341	1595	1849	254
.56633	1288	1493	1707	209
.59848	1319	1568	1816	249
.63246	1383	1681	1979	298
.66836	1416	1734	2053	318
.70630	1315	1602	1889	287
.74639	1249	1550	1852	301
.78877	1153	1436	1719	283

E-W

.83354	1088	1342	1597	255
.88086	1089	1334	1579	245
.93086	1057	1289	1522	233
.98371	1036	1276	1516	240
1.03955	1003	1178	1353	175
1.09856	989	1209	1429	220
1.16092	975	1194	1413	219
1.22683	930	1140	1350	210
1.29647	866	1085	1304	219
1.37007	764	957	1151	193
1.44784	674	851	1027	176
1.53003	582	725	869	143
1.61689	484	588	691	104
1.70867	419	484	548	65
1.80567	405	483	561	78
1.90817	428	523	618	95
2.01650	452	553	654	101
2.13097	485	599	713	114
2.25194	516	646	776	130
2.37977	495	613	732	119
2.51487	458	572	685	113
2.65763	392	489	585	96
2.80850	340	405	470	65
2.96793	303	349	395	46
3.13641	268	315	361	46
3.31446	253	296	338	42
3.50261	239	288	338	50
3.70144	217	259	301	42
3.91156	186	223	259	37
4.13361	162	192	221	30
4.36827	147	178	210	32
4.61624	133	162	190	28
4.87829	125	151	176	26
5.15522	119	142	165	23
5.44787	113	137	162	24
5.75713	107	133	159	26
6.08395	98	122	146	24
6.42932	90	110	130	20
6.79429	84	102	121	18
7.17999	77	92	106	14
7.58758	73	85	97	12
8.01830	71	83	95	12
8.47348	68	81	94	13
8.95450	65	83	100	17
9.46282	64	82	99	18
10.00000	62	78	94	16

RESPONSE SPECTRA - 5 % DAMPING (CM/S*S)
Z COMPONENT

PERIOD(S)	M	M+SD	M+2SD	SD
.04000	991	1238	1484	247
.04227	993	1240	1487	247
.04467	996	1243	1491	247
.04721	999	1247	1495	248
.04969	1002	1250	1499	249
.05272	1005	1254	1503	249
.05571	1010	1259	1509	250
.05887	1015	1266	1516	251
.06222	1021	1273	1525	252
.06575	1029	1281	1534	253
.06948	1037	1291	1546	254
.07342	1047	1303	1560	256
.07759	1060	1319	1577	259
.08200	1077	1339	1601	262
.08665	1100	1367	1635	267
.09157	1135	1412	1689	277
.09677	1198	1490	1782	292
.10226	1290	1579	1869	289
.10807	1345	1622	1899	277
.11420	1402	1665	1927	262
.12068	1510	1765	2019	254
.12753	1515	1769	2022	254
.13477	1574	1798	2022	224
.14243	1598	1831	2065	233
.15051	1585	1813	2041	228
.15705	1610	1822	2035	213
.16808	1632	1878	2124	246
.17762	1720	2051	2381	330
.18771	1916	2312	2709	397
.19836	2109	2582	3055	473
.20962	2202	2698	3195	496
.22152	2366	2860	3353	494
.23410	2809	3452	4096	644
.24739	3040	3769	4498	729
.26143	2996	3753	4510	757
.27627	2936	3727	4518	791
.29196	3129	3988	4846	859
.30853	3394	4244	5094	850
.32604	3303	4125	4947	822
.34455	3162	3855	4548	693
.36411	2851	3499	4146	648
.38478	2554	3226	3897	671
.40663	2347	3007	3667	660
.42971	2155	2663	3171	508
.45410	1976	2421	2866	445
.47988	1917	2395	2872	476
.50712	1830	2282	2734	452
.53591	1833	2309	2786	476
.56633	1805	2362	2919	557
.59848	1760	2308	2856	548
.63246	1622	2091	2560	469
.66836	1358	1766	2175	408
.70630	1134	1505	1877	371
.74639	951	1258	1566	307
.78377	878	1090	1342	252
.83254	785	1004	1223	219
.88065	744	947	1200	203

54

2

.93086	843	1056	1269	213
.98371	939	1163	1388	224
1.03955	1054	1345	1637	291
1.09856	1133	1466	1799	333
1.16092	1286	1607	1929	322
1.22683	1328	1623	1918	295
1.29647	1344	1608	1872	264
1.37007	1317	1565	1813	246
1.44784	1231	1439	1647	206
1.53003	1103	1327	1551	224
1.61689	1004	1267	1530	263
1.70867	918	1159	1400	241
1.80567	865	1084	1304	219
1.90817	782	991	1200	209
2.01650	679	846	1012	166
2.13097	603	751	900	149
2.25194	485	611	738	125
2.37977	373	471	589	98
2.51487	335	414	493	79
2.65763	284	349	415	65
2.80850	252	306	360	54
2.96797	235	279	323	44
3.13641	217	266	315	49
3.31446	200	239	278	39
3.50261	177	207	237	30
3.70144	162	185	209	23
3.91156	150	176	202	26
4.13361	140	169	198	29
4.36827	136	163	190	27
4.61624	131	153	175	22
4.87829	128	148	168	20
5.15522	129	155	181	26
5.44787	136	166	195	29
5.75713	140	178	216	38
6.08395	143	185	227	42
6.42932	147	186	226	39
6.79429	150	193	237	44
7.17999	150	193	237	44
7.58758	144	182	220	38
8.01830	140	174	208	34
8.47348	140	173	206	33
8.95450	138	176	214	38
9.46282	137	173	210	37
10.00000	132	167	202	35

N – S

.97086	1694	2234	2774	540
.92371	1660	2161	2662	501
1.03955	1606	2108	2610	502
1.09856	1549	2066	2583	517
1.16092	1512	1978	2443	465
1.22683	1413	1802	2191	389
1.29647	1269	1598	1927	329
1.37007	1142	1403	1663	251
1.44784	984	1203	1422	219
1.53003	794	932	1071	138
1.61689	676	808	941	133
1.70867	618	760	903	143
1.80567	600	747	893	146
1.90817	603	757	925	158
2.01650	664	851	1038	187
2.13097	733	936	1140	204
2.25194	737	950	1163	213
2.37977	715	944	1173	229
2.51487	660	885	1109	225
2.65763	572	763	953	191
2.80850	488	633	777	144
2.96793	418	532	647	115
3.13641	356	454	552	98
3.31446	306	381	456	75
3.50261	267	322	378	55
3.70144	234	277	321	43
3.91156	211	255	299	44
4.13361	202	245	288	43
4.36827	193	231	270	39
4.61624	185	222	259	37
4.87829	177	215	252	38
5.15522	175	213	255	40
5.44763	179	222	266	44
5.75717	184	231	273	47
6.08395	173	213	252	40
6.42932	167	203	239	36
6.79429	167	210	254	43
7.17999	166	206	246	40
7.58758	160	194	228	34
8.01930	155	185	214	30
8.47348	152	183	214	31
8.95450	146	181	215	34
9.46282	142	174	207	32
10.00000	135	165	194	29

Table 4 peak ground accelerations and Peak ground velocities

TABLE -4 PEAK GROUND ACCELERATIONS AND PEAK GROUND VELOCITIES

PARAMETER		E-W	Z	N-S
STATION : TEHRI (ORIGINAL MODEL)				
PEAK ACCELERATION CM/S/S	MEAN	494	908	970
	MEAN+1SD	592	1155	1297
PEAK VELOCITY CM/S	MEAN	74	146	151
	MEAN+1SD	87	322	338
STATION : TEHRI MODIFIED VELOCITY MODEL TO INCLUDE DAM MATERIAL				
PEAK ACCELERATION CM/S/S	MEAN	294	671	671
	MEAN+1SD	346	856	847
PEAK VELOCITY CM/S	MEAN	86	139	163
	MEAN+1SD	102	184	205

Table - 5 Pseudo relative response at selected periods (10 % damping)

TABLE - 5 PSEUDO RELATIVE RESPONSE AT SELECTED PERIODS (10 % DAMPING)

PARAMETERS	PSEUDO RELATIVE RESPONSE VELOCITY CM/S				PSEUDO RELATIVE RESPONSE ACCELERATION CM/S/S			
	1.0s	1.25s	1.5s	2.0s	1.0s	1.25s	1.5s	2.0s
STATION : TEHRI (ORIGINAL MODEL)								
E-W M	108	119	94	117	676	600	396	368
M+1SD	126	150	117	146	792	755	490	458
Z M	121	175	188	155	758	877	788	486
M+1SD	144	200	224	199	903	1006	937	626
N-S M	174	189	169	167	1096	948	712	526
M+1SD	193	218	199	215	1210	1097	834	675
STATION : TEHRI (MODIFIED VELOCITY MODEL TO INCLUDE DAM MATERIAL)								
E-W M	80	124	133	121	504	623	558	383
M+1SD	95	144	163	151	594	725	684	475
Z M	140	135	140	179	881	682	586	563
M+1SD	187	175	172	220	1178	879	720	690
N-S M	166	200	211	201	1042	1004	884	630
M+1SD	229	271	268	241	1441	1362	1123	757

Table - 6 Response spectra values at Tehri for epicenter at B Damping 10% Acceleration in cm/s^2 Velocity in cm/s

Vertical component

PERIOD	$S_a(t)$		$S_v(t)$	
s	M	M+SD	M	M+SD
.040	926	1121	6	7
042	928	1124	6	8
045	930	1128	7	8
047	932	1131	7	8
.050	935	1135	7	9
053	938	1140	8	10
.056	942	1145	8	10
059	946	1152	9	11
062	951	1159	9	11
.066	957	1167	10	12
069	963	1175	11	13
073	971	1187	11	14
078	981	1202	12	15
082	994	1221	13	16
.087	1016	1247	14	17
.092	1047	1286	15	19
.097	1093	1352	17	21
.102	1145	1435	19	23
.108	1192	1501	20	26
.114	1201	1496	22	27
.121	1207	1460	23	28
.128	1231	1441	25	29
135	1265	1443	27	31
.142	1274	1441	29	33
.151	1289	1478	31	35
.159	1332	1543	34	39
168	1368	1627	37	44
.178	1432	1721	40	49
.188	1505	1767	45	53
198	1596	1854	50	59
.210	1736	2026	58	68
222	1915	2267	67	80
234	2046	2426	76	90
247	2210	2613	87	103
261	2276	2666	95	111
.276	2295	2590	101	114
.292	2216	2600	103	121
309	2187	2780	107	137
326	2240	2881	116	150
.345	2246	2849	123	156
.364	2161	2701	125	157
.385	2018	2497	124	153
407	1904	2305	123	149
.430	1808	2128	124	146
.454	1660	1999	120	145
.480	1536	1895	117	145
.507	1492	1788	120	144
536	1426	1690	122	144
566	1361	1613	123	145
.598	1340	1650	128	157

632	1275	1576	128	159
668	1139	1391	121	148
706	986	1131	111	127
746	841	944	100	112
789	750	845	94	106
834	724	816	96	108
881	710	808	100	113
931	707	823	105	122
.984	736	878	115	137
1.040	808	960	134	159
1.099	873	1024	153	179
1.161	903	1044	167	193
1 227	887	1013	173	198
1.296	860	991	178	205
1 370	845	960	184	209
1 448	819	951	189	219
1 530	771	929	188	226
1.617	695	870	179	224
1.709	642	807	175	219
1.806	600	748	172	215
1.908	547	695	166	211
2.016	477	614	153	197
2 131	413	527	140	179
2.252	348	440	125	158
2.380	292	367	111	139
2.515	263	324	105	130
2.658	235	279	100	118
2.809	209	234	94	105
2 968	186	201	88	95
3.136	171	190	85	95
3.314	164	182	86	96
3.503	148	169	83	94
3.701	130	147	77	87
3.912	125	140	78	87
4.134	123	144	81	95
4.368	124	148	86	103
4 616	123	149	90	[illegible]
4.878	124	154	96	119
5.155	126	154	104	127
5 448	130	160	113	138
5.757	138	171	126	156
6.084	139	173	135	167
6 429	136	170	139	174
6.794	137	176	148	191
7.180	140	181	160	207
7.588	137	171	165	206
8.018	126	148	160	189
8.474	115	133	155	180
8.955	107	128	153	183
9 463	104	125	157	189
10.000	101	120	160	191

N-S component

PERIOD	S.(t)		S.(t)	
s	M	M+SD	M	M+SD
040	925	1138	6	7
042	926	1139	6	8
045	927	1141	7	8
047	928	1143	7	9
050	930	1144	7	9
053	931	1145	8	10
056	932	1146	8	10
059	934	1148	9	11
062	936	1150	9	11
066	938	1153	10	12
069	940	1155	10	13
073	943	1158	11	14
078	945	1161	12	14
082	949	1163	12	15
087	952	1165	13	16
092	957	1166	14	17
097	964	1170	15	18
.102	984	1195	16	19
108	1006	1235	17	21
.114	1022	1263	19	23
.121	1040	1288	20	25
.128	1049	1301	21	26
135	1047	1308	22	28
142	1066	1333	24	30
151	1097	1367	26	33
.159	1132	1408	29	36
.168	1172	1454	31	39
178	1210	1485	34	42
188	1273	1504	38	45
198	1340	1545	42	49
210	1407	1617	47	54
222	1462	1695	52	60
234	1406	1623	52	60
247	1364	1497	54	59
261	1387	1536	58	64
276	1406	1589	62	70
292	1406	1583	65	74
309	1551	1775	76	87
.326	1710	1980	89	103
345	1881	2187	103	120
.364	2073	2380	120	138
385	2186	2505	134	153
407	2176	2524	141	163
.430	2073	2424	142	166
.454	2003	2321	145	168
.480	1968	2305	150	176
.507	1942	2288	157	185
536	1861	2267	159	193
566	1796	2244	162	202
598	1842	2249	175	214

632	1848	2214	186	223
668	1816	2206	193	235
706	1700	2087	191	235
746	1572	1832	187	218
789	1500	1645	188	207
834	1456	1623	193	215
881	1308	1510	183	212
931	1180	1348	175	200
984	1103	1217	173	191
1 040	1080	1194	179	198
1 099	1034	1118	181	196
1 161	1020	1120	189	207
1.227	972	1113	190	217
1 296	903	1066	186	220
1.370	837	993	182	217
1.448	758	881	175	203
1.530	686	808	167	197
1 617	606	731	156	188
1.709	534	650	145	177
1.806	487	602	140	173
1.908	497	613	151	186
2 016	531	686	170	220
2.131	545	737	185	250
2.252	551	745	197	267
2.380	524	664	198	251
2.515	466	552	187	221
2 658	424	485	179	205
2.809	388	422	173	189
2.968	360	397	170	187
3.136	317	366	158	182
3 314	272	327	143	172
3 503	241	293	134	164
3 701	211	256	124	151
3 912	189	220	118	137
4 134	176	193	116	127
4.368	168	186	117	129
4 616	157	177	116	130
4 878	157	177	122	137
5 155	159	186	131	152
5.448	169	201	146	174
5.757	167	202	153	185
6.084	163	189	158	183
6.429	155	172	159	176
6.794	151	168	163	182
7 180	145	167	166	191
7 588	136	152	164	184
8 018	122	137	156	175
8 474	112	134	151	181
8 955	105	132	150	189
9 463	101	131	152	197
10 000	95	123	151	195

E-W component

PERIOD	$S_a(t)$		$S_v(t)$	
s	M	M+SD	M	M+SD
040	579	627	4	4
.042	580	628	4	4
.045	581	629	4	4
.047	582	630	4	5
050	584	631	5	5
053	585	632	5	5
.056	586	633	5	6
059	588	635	6	6
.062	591	637	6	6
.066	594	639	6	7
069	597	642	7	7
073	601	645	7	8
078	605	649	7	8
.082	612	655	8	9
.087	619	662	9	9
.092	629	671	9	10
.097	641	683	10	11
.102	652	697	11	11
.108	658	708	11	12
.114	653	704	12	13
.121	638	696	12	13
.128	631	683	13	14
.135	640	680	14	15
.142	652	684	15	16
.151	673	708	16	17
.159	699	741	18	19
.168	721	775	19	21
.178	725	805	20	23
.188	720	826	22	25
.198	709	813	22	26
.210	712	795	24	27
.222	731	805	26	28
.234	736	794	27	30
.247	749	814	29	32
.261	759	855	32	36
.276	775	871	34	38
.292	789	894	37	42
.309	815	930	40	46
.326	844	957	44	50
.345	896	1005	49	55
.364	983	1119	57	65
.385	1084	1218	66	75
.407	1130	1256	73	81
.430	1164	1324	80	91
.454	1193	1415	86	102
.480	1192	1463	91	112
.507	1196	1527	97	123
.536	1207	1555	103	133
.566	1195	1520	108	137
598	1118	1413	106	135

632	1060	1244	107	125
.668	1036	1122	110	119
706	980	1079	110	121
746	889	996	106	118
.789	819	928	103	117
.834	762	888	101	118
.881	738	849	104	119
.931	718	813	106	120
984	677	789	106	123
1.040	674	801	112	132
1.099	671	815	117	143
1.161	650	823	120	152
1.227	623	788	122	154
1.296	557	692	115	143
1.370	483	583	105	127
1.448	430	524	99	121
1.530	377	472	92	115
1.617	355	442	91	114
1.709	349	437	95	119
1.806	347	440	100	126
1.908	355	445	108	135
2.016	370	460	119	148
2.131	379	461	129	156
2.252	373	459	134	164
2.380	360	444	136	168
2.515	328	407	131	163
2.658	290	342	123	145
2.809	263	302	117	135
2.968	248	291	117	137
3.136	232	271	116	135
3.314	209	244	110	129
3.503	189	217	105	121
3.701	172	192	101	113
3.912	152	163	95	101
4.134	135	141	89	93
4.368	120	129	84	90
4.616	107	120	79	88
4.878	102	111	79	86
5.155	94	105	77	86
5.448	85	98	74	85
5.757	78	88	71	81
6.084	73	83	71	80
6.429	70	79	71	81
6.794	65	73	70	79
7.180	61	69	70	79
7.588	61	69	73	84
8.018	60	69	77	88
8.474	60	69	81	94
8.955	58	74	82	105
9.463	57	76	85	114
10 000	55	73	88	116

APPENDIX - I

SIMULATIONS FOR AN ALTERNATIVE VELOCITY MODEL TO ESTIMATE FORCES ACTING ON THE BODY OF THE DAM

At the suggestion of Prof. R.N Iyengar it was decided to obtain the accelerogram simulations for the case in which the top low velocity layer in the original velocity model for Tehri is replaced by an equivalent layer representing the construction material of the dam and thickness equal to dam height

Thus the top layer having a thickness of 50 m was replaced by a layer of 260 m thickness and having the following parameters:

V_p = 1.05 km/s
V_s = 0.31 km/s
Q_p = 15
Q_s = 8
ρ = 2.36 gm/cc

The peak ground accelerations and velocities have dropped as shown in Table 4. On the other hand the spectral values in the response spectra at periods longer than 1s have increased (see Table 5). Thus while the total energy released in the earthquake remains the same as is defined by the static stress drop. it is redistributed in the manner shown above. The seismic forces are more severe in the period range covering the natural period of the dam for the case of the velocity model suggested by Prof R.N Iyengar. The corresponding mean response spectra for the N-S component is shown in Figure 8.

APPENDIX - II

STATE OF ART METHODS AND TECHNOLOGIES FOR QUANTIFYING EARTHQUAKE HAZARD, DAM DESIGN AND ITS TESTING

EARTHQUAKE HAZARD

With the progress in the understanding of the geological processes driving the earthquakes, the physics of the earthquake sources, and the wave propogation phenomena the estimation of earthquake hazard has now attained a high level of sophistication

Generally the following types of hazard analyses are carried out.

1) Probabilistic methods

These may comprise of the following types of estimations. Probabilistic hazard estimates in which the probability of exceeding a certain level of ground motion characteristic in a given time window are obtained The ground motion parameter may be a single parameter like the peak ground acceleration, peak ground velocity etc or multiparameter which may include several ground motion parameters and earthquake magnitudes The estimation of the uniform hazard response spectrum where the levels of spectral accelerations for a given probability of exceedence are obtained from the analysis of empirical data set

2) Hybrid methods

In hybrid methods one utilizes theoretical analysis along with data set from one seismotectonic region in order to estimate the hazard for another region having different characteristics in order to estimate seismic hazard

3) Theoretical modeling

In this procedure the available seismological and geological information is combined to obtain estimates of site specific hazard estimates in terms of strong motion time histories and response spectrum The above procedures depend on the following types of informations.

Geological Processes in Occurrence of Earthquakes:

The study of the geological process is essential identify the seismo-tectonic regime governing the earthquake processes. For example if it is compressive the resulting earthquake hazard environment will be different than when it is extentional The significant faults will be of the thrust type in the former while of the normal type in the latter regime This has a significant influence on the nature of ground motions. The study also establishes the geometrical(spatial) relationship of the faults with the site in question.

Earthquake Parameters

Magnitude is a widely used quantitative measure of the strength of earthquakes. It's informational shortcomings arise from the fact that it is based on the amplitude of a single frequency in the spectrum of the seismic wave Other important parameters describing an earthquake source are the strain energy release, fault slip, stress drop, source dimension, moment and radiated seismic energy These parameters play an important role in seismic hazard estimation

Earthquake Occurrence Rates

The estimation of the occurrence rates of the earthquakes associated with the faults, or with the seismogenic zone requires establishing appropriate magnitude-time windows for which the data sets are homogeneous, i.e., have complete reporting of earthquakes The above needs to be supplemented by the geological estimation of the repeat times of significant earthquakes

Strain Rates

The estimation of the state in which the fault system is in the strain cycle allows one to determine the potential hazard from the fault or seismic zone Thus is established on the basis of the paleoseismic studies, historical seismicity, and geodetic measurements to estimate the strain accumulation rates

Estimation of Maximum Earthquake

The maximum historical earthquake defines the lower bound for Maximum possible earthquake. The upper bound or the maximum possible earthquake is determined by the earthquake processes, and the size of the possible rupture area The size of the rupture areas may be controlled by the earthquake generating process and the geological structure. The physical basis of estimating Maximum Possible earthquake is give by the following fundamental relation.

$$M_o = \mu . A . D$$

where M_o is the seismic moment, μ is the shear modulus, A is the area and D is the average displacement

Characteristic Earthquakes

Some faults are prone to cause relatively frequent large magnitude earthquakes lying in a narrow range These earthquakes are not deducible from simple extrapolation of recurrence relation of smaller magnitude earthquakes. Special studies are needed to define them as they affect the seismic hazard in a significant manner.

Characterizing the Earthquake Source Mechanisms

The fault type, radiation pattern and directivity are important parameters that determine the nature of strong motions in the near field. In thrust earthquakes there is focusing in the wedge edge causing amplification of strong motions. Also the radiation pattern in this case is such that the maximum of shear wave energy reaches the free surface of the hanging wall. Thus strongest ground motions occur in thrust earthquake environments. Directivity causes an increase in amplitudes and a shift of the dominant frequency of the waves towards higher end, and is an important factor in controlling the near field strong ground motions.

Stress Parameter

The maximum accelerations are proportional to stress drop as well as the moment of the earthquake.

Path Effects

The velocity, density and Q structures control the path effects. In the near field the path effects may be less important as compared to the local site amplification effects. Particularly the effects of Q may not be important in the near field

Local Site Amplification Effects

Soft soil sites introduce amplification due to large impedance contrasts as well reverberations at the resonance frequencies Such effects can produce amplifications by factors as high as 50 as was the case in Mexico city for the 1985 Mexico earthquake. Motions in the middle of the valley may be up to six times larger than at the edges

Topographic Effects

These are complex effects However top of ridges can amplify ground motions by 1.5 to 30 times This effect is amplitude dependent and the effect is larger for horizontal component than for vertical

Preferentially Rich Spectrum of the Source

Earthquake source spectrum can be preferentially rich in frequencies that coincide with the resonant frequency of the site and it may precipitate a calamity Example Mexico 8.5 earthquake of 1985

Estimation of Peak Ground Motions

The peak ground acceleration depends not only on distance of the site from the earthquake but also on the magnitude of the earthquake, nature of source mechanism and local site geology Accordingly for regression analysis of the observational data expressions of the type given below are used

$$\ln y = a_0 + a_1 f(M) + a_2 g(r) + a_3 F + a_4 h(s)$$

where y is the peak ground acceleration at the site, a's are constants, M is magnitude, r is epicentral distance, site geology, f(.), g( ), h(.) are functions, F is specifying fault type (normal, strike slip or thrust)

Several regressions are available. However, one has to find one that is representative of the region under consideration. Modern trend is to use distance from fault edge or the nearest distance from the fault in such regressions as against the earlier usage of the epicentral distance.

Peak accelerations which are higher by 50% have been recorded in the near field(distance <~30km) in the hanging wall of thrust earthquakes than those predicted by the available regression relations1. Brune2 also reports wedge effects which substantially amplify ground motions in the overthrusted hanging wall from experiments on physical models.

Use of Fixed Shape Response Spectrum (FSRS)

Often FSRS is used by anchoring it to PGA or some derived parameter from PGA The shortcoming of the use of FSRS is that it ignores the information on earthquake magnitude, its source characteristics which includes the source spectrum and durations of source time function, velocity - Q structure, source- site distance and local site geology Thus there is no obvious way that one may ascertain whether it is likely to adequately represent the earthquake hazard for the site under consideration

Other uncertainties enter this procedure in adopting the peak ground acceleration to anchor the FSRS Firstly there are uncertainties in the estimates from regressions which are based on the available data sets from widely differing geological and seismic environments, and secondly the procedures for obtaining an 'effective PGA' from this PGA are not well defined.

nsideration of Uncertainties

Random uncertainties These are log normally distributed and may be estimated accordingly

Physical nature of problem e g . the uncertainties about the location of faults. return periods of earthquakes etc

Systematic or modeling uncertainties This includes uncertainties in scientific understanding, e g what would make a feature more seismogenic etc Further it includes informational uncertainties. e g the choice of Q. maximum earthquake etc

October 8, 1997

Sub: SEISMIC SAFETY OF TEHRI DAM clarifications and comments in regard to the issues raised at the June 27, 1997 meeting (vide Aide Memoir sent by Prof. Nigam)

Some concerns were raised at the last meeting regarding the realism of the estimated ground accelerations at the Tehri dam site in the wake of a great earthquake, as well as that of a plausible response spectrum that would be consistent with the nature of perceived earthquake threat. We state below our considered evaluation of these issues

1. Numerical Estimates of Seismic Hazard at the Tehri dam site:

There was a concern expressed at the last meeting of the committee that the estimated values of ground accelerations at the Tehri dam site being the convolution of several factors, may not represent a realistic value for testing the dams' performance against it. We have accordingly reexamined the validity of the 4 numerical parameters assumed for the above analysis. Specifically, these 4 parameters are

a) The most probable magnitude of the great earthquake that may rock the region over the next 100 years (M)

b) The distance (d) of the Tehri dam site from the rupture plane of a great earthquake. The typical aereal extent of such earthquakes now widely accepted as being about 250 x 100 km is, on the basis of current seismological knowledge, not much open to question

c) The value of the dynamic stress drop assumed to occur in such earthquakes (100 bars).

d) The values of seismic velocities and attenuation factors in the strata underlying the Tehri region, or the model of wave velocities and Q

It is now a fact well acknowledged that definitive knowledge of the geometry and location of the rupture plane in this part of the Himalaya, does not exist, such as that mapped in Nepal. Nor, do we have a detailed knowledge of the seismicity of the region even for the past 3.5 decades of instrumental seismology. Of historical seismicity too, our knowledge is limited to the occurrence of only major earthquakes whose magnitudes have now been estimated from a careful analysis of all information that could be gleaned from reports from different sites..

The above 4 parameters of future great earthquake have therefore been estimated applying our current understanding of earthquake processes and the tectonic framework of the region, constrained by the condition that they must be consistent with all available data and information, particularly that yielded by recent earthquakes whose validity is now reasonably well established. We believe that the values used for the estimates of ground accelerations (vide document submitted at the last meeting) are as close to reality as it is logically possible to infer, free from arbitrary assumptions. However, we further clarify the data and the physical reasonings on which these calculations are based:

2. **Data and scientific basis underlying the estimation of the 4 Earthquake parameters used in hazard quantification**

a) Magnitude

The magnitude of the great earthquake, perceived to be the main threat to Tehri dam has been estimated by taking into consideration the following

i) Historical seismicity: this shows that there have been four great earthquakes (8.5≤M≤8.7) along half of the 2400 km long Himalayan seismic belt in the past 100 years.

Current understanding of the geodynamics of the Himalaya which drives the earthquakes: Modern analyses of the rate of strain accumulation at the Himalayan plate boundary where great earthquakes occur and where the Tehri dam site is located, show that it takes 250-500 years for the accumulation of sufficient strain to produce a great earthquake of magnitude (8≤M≤8.7, slip 5 to 10m). Since the Garhwal sector of the Himalayan belt where the Tehri dam site lies has not been ruptured by a great earthquake atleast for 400 years and probably longer, the region should at present have sufficient strain available to cause a great earthquake (M 8.5) within the next 100 years, i.e. within the life time of the dam.

ii) Physics of earthquake process: This is for example embodied in the universally observed Gutenberg-Richter frequency magnitude relationship which implies that the strains mentioned above cannot be released by just a few earthquake of smaller magnitude. For, even if strain were to be so released in a large number of small instalments by earthquakes of magnitude 7, for example, it would take one hundred of them to relieve the accumulated strain in the Garhwal Himalaya itself, i.e about one, M7 event every 5 years There is no empirical evidence of this happening any where, while large strain release by great earthquakes is common occurrence.

iii) It is now reasonably well established that the causative ruptures of great Himalayan earthquakes occur along the plate boundary fault under the lesser Himalaya. There is no evidence, geological or geodetic, of substantial aseismic processes like plastic deformation or creep taking place in the region which could have released this strain thereby forestalling the preparation of a great earthquake In fact, recent GPS measurements in Nepal have shown that negligible creep takes place in the Lesser-Himalaya and the strain accumulation is therefore primarily elastic. This accumulated recoverable strain can only be released by a great earthquake as has happened in the eastern and western parts of this plate boundary four times in the past 100 years.

iv) The magnitude adopted for the estimation of the seismic hazard is the mean value of the magnitudes of these 4 similar great earthquakes in the Himalaya.

b) The location, orientation and the geometry of the rupture plane is constrained by the following data:

i) The seismic reflection profiles in the sub-Himalaya in the south show the existence of a detachment plane dipping gently to the north In the Lesser-Himalaya, the well determined earthquake hypocenters also define a plane gently dipping to the north at a similar angle as the detachment mapped in the sub-Himalaya, and is accordingly interpreted to be the continuation of the detachment plane Below this plane there is virtually no seismicity. At the northern edge of the Lesser-Himalaya well determined hypocenters of moderate earthquakes are at depths of about 15-20 km and tie in with the detachment plane defined above.

ii) Geodetically determined co-seismic levelling changes Precise geodetic levelling was carried out along the Saharanpur Mussoorie line in the years preceding and following the great Kangra earthquake. The difference in levels at points along this line are consistent with calculated displacements (the Kangra rupture) along the detachment plane which constitutes a major fracture system in the Himalaya, facilitating convergence.

iii) The fault plane solutions of moderate earthquakes consistently demonstrate thrust faulting on a shallow dipping plane, which confirms at underthrusting along the detachment is the most dominant geodynamic process operating in the region.

c) **The dynamic stress drop assumed to be 100 bars:**

This is a very reasonable value consistent with globally determined stress drops. Anderson (1997) has shown that the stress drop parameter used in the computation of ground accelerations corresponds to the dynamic stress drop in the sub-events and its value lies between 2 to 4 times the value of the static stress drop in an earthquake. The static stress drop of the great Himalayan earthquake is approximately 60 bars which is consistent with the empirical data for earthquakes in the plate convergence zones. The value adopted by us for the dynamic stress drop is only about 1.6 times the static stress drop and therefore is on the lower side of the range of possible values for this parameter.

d) The velocity and Q model:

These are based on hard seismological information, coupled with modelling of the acclerograms recorded int he 1991 Uttarkashi earthquake. This is not much open to question

Design spectrum

The design spectrum used by THDC leaves several questions unilluminated which are cause for concern.

The following comments are accordingly made to elicit greater clarity:

a) The response spectrum is obtained by taking into account hypocentral distances from surface expressions of faults that are 26-48 kms away from possible earthquakes of magnitudes ranging from 6.5-7.25. An envelope was drawn to encompass all the four response spectra. However the envelope response spectrum remains essentially representative of a magnitude 7 earthquake at an epicentral distance of 40 km. In our opinion therefore, it cannot be expected to represent the correct shape in respect of earthquakes of magnitudes greater than 7 25 at a hypocentral distance of less than 26 km.

Correspondingly, the shorter duration of strong ground shaking implicit in this response spectrum will be incompatible with that caused by a stronger earthquake, as it is proportional to the long dimension of the fault area. The long dimension of a magnitude 7 earthquake is of the order of 30 km while the dimensions of the rupture zone of a M8.5 earthquake is of the order of 80x240km.

b) Since the main earthquake hazard to Tehri arises from an earthquake of M8+ at a closest distance of 14 km vertically below the Tehri dam site, the above procedure for the design of response spectrum appears to be wide off the mark.

c) It is presumed that some empirical relation has been used for deriving the response spectrum. It would be enlightening to see the data base used for these empirical relations and how they may be related to the effects caused by a magnitude 8.5 earthquake at a distance of 14 km

d) The concept of an epicentral distance in a situation as prevails beneath Tehri, that is, the existence of widely spread detachment (rupture zone) at a depth of 14 km doest not appear to be valid for determining a response spectrum for this situation.

e) This procedure also does not take into account the effects of fault plane solution, and the rupture propagation both of which have a great influence on the radiated energy in seismic waves.

f) Also, it is not clear how the local site effects, which in the case of Tehri appears to be high by a factor of 2 in the period range of interest of the Tehri dam (as seen from the 1991 Uttarkashi earthquake data) has been taken into account.

g) Under these circumstances the use of an upscaled version of the design response spectrum to test the stability of the dam may not satisfactorily resolve the issue of its seismic safety, in the event of a great earthquake rocking the region. The estimated probability (0 59) of occurrence of such an earthquake is rather high.

h) In the dynamic tests the value of the material parameters were adopted to be the same at the nodes, i.e. without any variation as would be expected to occur in actual construction. What is the range of this variation in practice, i.e. what percentage? And if such a variability were to be introduced randomly in the model what would happen to the response? Will there be an increased possibility of nucleation of instabilities due to such heterogeneities which cannot be avoided?

(Ramesh Chander) (K N Khattr) (V K. Gaur)

Reference:

J.G. Anderson, 1997, "Seismic Energy and Stress Drop Parameters for a Composite Source Model, BSSA, Vol. 87, No. 1, pp 85-96.

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FURTHER COMMENTS ON THE REALISTIC NATURE OF THE SIMULATED ACCELEROGRAMS AND PROBABILITY OF THEIR OCCURRENCE DURING THE LIFE TIME OF TEHRI DAM.

~~[illegible]~~

1) The accelerograms simulated for the M8.5 earthquake by Gaur et al. show ground motion characteristics that are very consistent with the characteristics obtained by a different approach often adopted by the engineering community, viz. by obtaining the various percentile response spectra.

The accompanying figure compares the 10% damping response spectra obtained in the simulations with the 84% and 50% percentile response spectrum for M8.5 event at a distance of 15 km obtained by Idriss(1991).

We note that while the response spectrum of the N-S component closely hugs the Idriss spectrum at the 84% level, the E-W spectrum follows the 50% Idriss spectrum. The two levels for the N-S and the E-W components are due to radiation pattern effect of the earthquake source process.

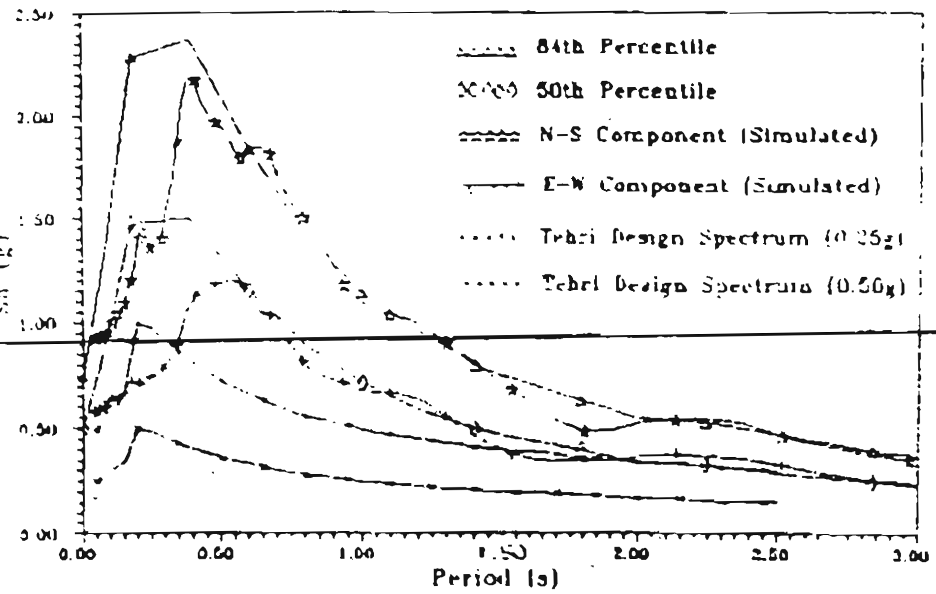
Therefore the simulated accelerograms for the N-S component are a realistic representation of 84% level ground motion expected at Tehri dam site.

We also note that the 0.5g Tehri Design spectrum is way below the 50% Idriss spectrum.

2) By definition the Maximum Credible Earthquake (MCE) for any region has a return period of greater than 10,000 years. The MCE for Himalaya may be over M9. The return period of M8.5 earthquakes in the region is of a few hundred years. Furthermore the probability of such an event occurring in Garhwal Himalaya with in the life time of the Tehri dam is 0.59. Thus a M8.5 event cannot be designated as a MCE for the region. It is appropriately a Safety Evaluation Earthquake(SEE) which is having a very high probability of occurring with in the life time of the earthquake.

K. N. Khattri

10% DAMPING



Idriss (1991) response spectra at 50th and 84th Percentile for M 8.5, Distance R 15 Km.
Tehri design spectrum anchored at 0.25 g and 0.50g (for testing).
The mean N-S simulated acceleration spectrum has a PGA of 0.970g
The mean E-W simulated acceleration spectrum has a PGA of 0.494g.

ANNEXURE-7

DESIGN OF TEHRI DAM

BACKGROUND NOTE

B.L. JATANA
Technical Consultant
(NJPC, WAPCOS, THDC etc.)
Engineer- in - Chief (Retd.)
Irrigation Department, U.P.
Ex- Executive Director
THDC Ltd., Rishikesh

DESIGN OF TEHRI DAM

1.0 TEHRI DAM PROJECT

1.1. The Tehri dam project, which envisages creation of storage on river Bhagirathi was first conceived in 1949. It was , however, in 1961 that detailed investigations were taken up by Investigation unit of U.P.Irrigation Department and Geological Survey of India. Detailed Project Report for the scheme was finalised by U.P.Irrigation Department to Govt. of India in 1969. The project envisaged construction of a high storage earth and rockfill dam, a chute spillway on right bank and an underground Power house with installed capacity of 600 MW. The project was technically cleared by Central Water & Power Commission and finally approved by the Planning Commission in 1972. Administrative approval of the project was accorded by U.P.Govt. in 1976, but advanced action on the project was authorised from 1971 onwards.

Subsequently, the scope of project was revised to meet the requirements of peak power in U.P.Power Grid. The installed capacity of Power House was increased to 1000 MW in the first stage. This is to be increased to 2400 MW, after the completion of second stage of project, which envisages construction of another dam at Koteshwar, downstream of Tehri, a surface power house at its toe with a capacity of 400 MW and another underground power station at Tehri with reversible turbines with a total capacity of 1000 MW.

1.2 The project was initially being executed by U.P.Govt.(GOUP) under State Plan. In 1986, it was decided between GOI & GOUP to execute the project jointly. In 1988, Tehri Hydro Development Corporation Ltd.(THDC) was set up as Joint Venture of GOI & GOUP with the responsibility of executing the project. The project was, therefore, transferred to THDC in June' 1989.

In November, 1986 an agreement for implementation of the project was entered into between Govt. of India and USSR, under which USSR was to provide technical assistance for construction of Tehri Dam and Spillways and to execute on 'turnkey' basis the two underground power houses at Tehri Dam and a surface power house at Koteshwar. Due to collapse of Soviet Union in 1991, this agreement has since lapsed. GOI has since decided to execute the project with their own resources and presently, execution of stage I project works has been taken up:

2.0 **AGENCY FOR DESIGNS & FIRMING UP OF DESIGNS FOR MAJOR PROJECT COMPONENTS**

2.1 After the clearance of the project, U.P. Government created organisation for construction of Tehri Dam, which was headed by a Chief Engineer. Construction of infrastructure works-Project road, construction camps, facilities were taken up and detailed pre-construction investigations were started for preparation of detailed designs of project components, within a span of five years, designs for diversion works were finalised and tenders invited for construction of diversion tunnels. Actual excavation work for tunnels was started in 1978-79 when funds were made available. This was followed up with start of work on the Head Race tunnels.

2.2 The design work for the project was taken up in 1972, when a design circle was created by Irrigation Department at Roorkee. Later on, the work of preparation of designs was entrusted to Irrigation Design Organisation, Roorkee, which was set up by GOUP in 1976 for designing of all multipurpose and Hydro Power projects in the State. In view of the importance of this mega project, GOUP, in August, 1973, constituted a Board of Consultants to review and advise on problems connected with design and construction of Tehri Dam. The Board had Dr.A.C.Mitra, Engineer-in-chief (Retd.) as its Chairman. Among its members, it included following two world renowned dam experts:

Dr.J.B.Cooke, USA- Embankment Dam Expert

Dr.I.L.Mueller, West Germany-Rock Mechanics Expert

The other members of the Board were:

Shri P.M.Mane, Retd.Member(Design & Research),CW&PC

Dr.Jai Krishna, Vice Chancellor, University of Roorkee

Shri B.R.Palta,Chairman,Bhakra Management Board

Chairman, Central Water & Power Commission

Engineer-in-Chief,Irrigation Department, U.P.

Shri Manohar Singh, Chief Engineer,Tehri Dam-Member Secy.

During the period 1973 and 1974, Board held two meetings. Dr.Mueller & Dr.Cooke subsequently gave further advise relating to various issues pertaining to Tehri project design. As a result following major decisions were taken for firming up project design.

<u>Dam</u>

- The type of dam at Tehri-Earth and Rockfill dam was considered appropriate from considerations of safety, geology, seismicity, available material and project economy.

- Inclination of core and core thickness for the dam was approved. Dr.Cooke gave advice on various problems relating to design of dam section- zoning, filter design parameters, Free Board.

Spillway

- Dr.Cooke favoured provision of open spillway in preference to Tunnel spillway on consideration of hydraulic performance.He considered hill slope excavation required for seating the chute spillway feasible and gave guidelines in this regard as well as for dimensioning & hydraulic design criteria for spillway.

Water Conductor System & Power House

- Guidelines about the design of water conductor system were given. Dr.Cooke gave advise regarding size of power house cavities, support system for cavities etc.

Subsequently, after 1978, the problems relating to design of Tehri dam project were referred to another Board of Consultants, which was constituted for projects in Ganga Valley. This Board had been rendering advise on design and construction aspects of Tehri dam till the time execution of project was with Govt. of U.P.

2.3 For finalising the main project concepts, design criteria and design parameters for design of individual structures, design studies were made by the Irrigation Design Organisation and Design Memoranda submitted to Board of Consultants periodically, seeking their advice on specific points. After obtaining Boards recommendations/ suggestions, detailed designs were finalised and construction plans issued to the Project Construction Organisation for execution. During the period 1979-80, a number of important issues relating to design of dam-dam curvature, founding of dam core on concrete pad, design of coffer dam, permissible fines in dam shell material, design criteria for filters, processing of core material etc. were studied, deliberated upon and final decisions taken.

2.4 Irrigation Design Organisation, Roorkee, continued to be responsible for designs of Tehri Dam Project till the take-over of the project by Tehri Hydro Development Corporation Limited, in July, 1989, whereafter, designs for Tehri dam and spillways were taken over by Design & Engineering Department of THDC.

3.0 IMPROVEMENTS IN PROJECT DESIGN CONCEPTS TAKING INTO ACCOUNT GLOBAL EXPERIENCE

3.1 It is noteworthy that when work on Tehri Dam project was taken up in 1970s, there were only a few precedents for High embankment dams in the World. In fact, era of High Embankment dam began in the 1960s with advances in Soil Mechanics, Analytical methods using computers and development of large size earth-moving equipment, which made earth and rockfill dam, economical competitive alternative vis-a-vis other type of dam, for large dam structures. In U.S.A, the highest embankment Dam-Oroville (236m) was completed by 1970. Construction of highest dam structure so far Nurek Dam (300 m) was taken up in Soviet Union in 1960s. In canada, 242 meters high Mica dam was completed in the seventies.

3.2 In view of intricate problems of design and construction involved in execution of Tehri Dam Project on account of its unprecedented height, steep abutments, complex geology and seismicity of the area, Govt. of U.P. with the approval of Govt. of India, deputed a composite team of senior engineers of Tehri dam project and Central Water Commission to visit projects of comparable magnitude in Europe, North and South America to have first hand knowledge of experience gained on execution of High Embankment

Dams and Large underground work. The team visited High embankment dams in France, U.S.A, Columbia and Mexico and held discussions with Designer Firms in France, U.K., Canada, U.S.A., Colombia, Mexico regarding design and construction aspects and about post- construction performance of these projects. This interaction was extremely useful and ultimately led to firming of very important design decisions relating to dam core, galleries for foundation, grouting and drainage, design of chute spillway, provision of a low level outlet, multiple spillway arrangement instead of a single chute spillway. The overall design concept and additional features introduced have tremendously enhanced overall safety of the dam.

4.0 ASEISMIC DESIGN OF TEHRI DAM

4.1 It was known right from the day, the project was conceived that Tehri dam location was in a region, which is prone to seismic activity. In evolving the design for dam and appurtenant works, due cognizance has been taken of this fact and structures have been designed accordingly.

In the preliminary design studies, stability analysis of dam section for earthquake loads was carried out by adopting psuedo-static method. The seismic design parameters for this analysis were adopted on the basis of the National Standing Committee for recommendation of Design Seismic Parameters in River Valley scheme, in August, 1984. The Committee, while recommending a seismic design co-efficient of 0.12g for Tehri dam, had observed as follows.

" A value of 0.12g may be taken tentatively for preliminary studies, to be followed up with dynamic analysis and taking into consideration the three dimensional effect, on the period of the dam and the project authority may come up the results when it is ready. "

4.2 After analysing the stability of slopes for the recommended seismic coefficient of 0.12g, detailed studies were taken up for dynamic analysis of Tehri dam. As dynamic analysis is a specialist's job, Irrigation Deptt. U.P. who were responsible for execution of Tehri dam at that time, referred these studies to Department of Earthquake Engineering (DEE), University of Roorkee(U.O.R), Roorkee. The studies carried out by the Department of Earthquake Engineering, U.O.R., comprised of site specific assessment of seismicity, testing of fill materials for determining dynamic properties & carrying out detailed dynamic analysis.

4.3 In persuance of the intergovernmental agreement on economic and technical cooperation for Tehri Hydro Power Complex signed between the Govt. of India and Govt. of U.S.S.R. in Nov'1986, the Soviet Consultants, in order to have an independent appraisal of safety aspect of Tehri dam were asked to review the seismic stability of Tehri dam based on state-of-the-art methodologies / techniques. The Soviet Consultants carried out whole gamut of seismic studies comprising of review of seismicity, dynamic testing of materials on large size dynamic triaxial testing machine and sequential, non-linear elasto-plastic dynamic analysis of the dam. These studies were carried out by Hydro project Institute, Moscow, who were the consultants for this job by the Soviet side.

4.4 Brief account of the studies carried out both by the Department of Earthquake Engineering, UOR, Roorkee and Hydroproject Institute, Moscow is given below.

Dam Section

The dam section for the 252.0m high dam (above river bed foundation) comprises of moderately inclined core with zones of filters and transition material both on the upstream side and downstream side followed by outer shells of gravelly materials. The outer slopes of dam are 2.5:1 upstream and 2:1 downstream. The dam core is a thin core of 0.3H thickness flared to 0.5H thickness at the base and comprises of gravel sand clay mixture obtained by blending. The filter comprises of two layers, fine layer comprising of fine to medium sand and coarse layer comprising of well graded mixture of sand and gravels upto 80 mm size. The shells in the major portion comprise of a well graded sand gravel mixture with silt content restricted to 5% and sand content restricted to 35% and 40% in the u/s and d/s shells. Initially tested dam section is shown in Fig.1. Dam section with optimised core position after the studies is shown in Fig.2.

5.0 STUDIES BY DEPARTMENT OF EARTHQUAKE ENGINEERING, UOR

The Department of Earthquake Engineering carried out the detailed studies in four steps viz (i) Establishing the seismicity of project area, (ii) Determination of dynamic properties of dam fill materials, (iii) Liquefaction studies for dam fill materials and (iv) Carrying out dynamic stability analysis.

5.1 Site Specific Assessment of Seismicity

5.1.1 Estimation of Peak Ground Acceleration :

The studies for seismicity carried out by the Department of Earthquake Engineering, UOR on the basis of tectonic input provided by Geological Survey of India (GSI) are capitulated below.

Tehri dam reservoir region falls between two main regional tectonic features, Main Boundary Fault (MBF) on the South-Western side and the Main Central Thrust (MCT) on the North-Eastern side. Besides these, there are some other tectonic features in the vicinity of dam site, the important among them being Srinagar Thrust which has a strike continuation of over 100 km and lies at a distance of about 6 km towards North from the dam site.

To study the seismogenicity of these structural features, a study of micro earthquakes using short term recording through portable high frequency high gain instruments was got conducted through the Department of Earthquake Engineering, University of Roorkee. The observations made indicated that MBF did not show any seismic activity while MCT had sporadic activity scattered all along the length. Srinagar thrust had shown association with only few events at a distance of about 20 km from Tehri.

Based on the seismo-tectonic set up around Tehri dam site DEE,UOR considered four sources of earthquakes. It was assumed that the earthquake of magnitude 0.5 degree more than the maximum historical observed magnitude may occur along any major tectonic lineament. A focal depth of 20 kms was assumed. Effective peak ground acceleration for the various source zones was worked out as given in Table-1 using Magnitude - Distance - Acceleration relationship proposed by McGuire.

TABLE - 1

ESTIMATION OF PEAK GROUND ACCELERATION

Seismic Source	Magnitude	Focal Depth (Km)	Hypocentral Distance (Km)	Effective Peak Ground Acceleration
Srinagar Thrust Frontal	6.5	20	26	0.19 g
MCT (Main Central Thrust)	7.0	20	37	0.20 g
Northern Boundary of Himalayan Frontal Thrust	7.0	20	27	0.25 g
Southern Boundary of Himalayan Frontal Thrust	7.25	20	48	0.19 g

Seismic risk of Tehri dam project site was also evaluated following the probabilistic approach taking into consideration the data of earthquake occurrence from 1917 onwards. The analysis has indicated that the effective Peak Ground Acceleration for 100 yrs. service life would be 0.07 g, 0.08 g and 0.23 g with an exceedence probability of 0.67, 0.50 and 0.25 respectively i.e.there exists 67%, 50% and 25% chance that the actual PGA will exceed 0.07 g, 0.08 g and 0.23 g in 100 yrs.(Refer UOR Report - Copy available with Experts Group)

5.1.2 Response Spectra and History of Ground Motion

In absence of record of strong motion for earthquakes of the region, response spectra were worked out keeping in view the expected range of predominant frequencies and dynamic amplifications for various levels of damping. Response spectra for all the four source zones were selected and an envelope of these was adopted as the response spectra for the design purpose. In plotting the response spectra, the expected range of predominant period has been kept from 0.1 sec. for the earthquake at 26 km distance to 0.4 sec. for the earthquake at 48 kms distance. Damping has been taken as 10% of the critical. The response spectra is shown in Fig.3.

Artificial accelerogram has been generated to match the shape of the spectra which is shown in Fig.4.

5.2 **Dynamic Parameters for Dam Fill Material**

For carrying out dynamic analysis, values of strain dependent shear modulus are needed. In the absence of suitable laboratory equipment, field tests were devised to determine the value of dynamic shear modulus at various shear strain levels ranging from 10^{-2} to 10^{-6}. These tests were carried out in the borrow areas for core and shell materials. Following three tests were carried out :

i) Block vibration tests

ii) Wave propagation tests

iii) Vertical Dynamic plate load tests.

From the data obtained from various tests, a relationship between dynamic shear modulus and shear strain was established both for core and shell materials, after reducing the results to a common confining pressure of 1 kg/ cm^2. Details of these tests are given in the relevant reports issued by UOR, copies of which have been given to Experts Group by THDC.

5.3 **Liquefaction of Fill Materials**

The shell material for Tehri dam has silt content upto 5% and sand content up to 40%. Similarly the core material would be a mixture of clay, silt, sand and gravels. To investigate the possibility or otherwise of liquefaction of the shell or core material or appreciable reduction in shear strength, due to development of excess pore water pressure during occurence of estimated Maximum Credible Earthquake (MCE), Liquefaction studies were conducted on these materials with the help of a shake table.

The equivalent sinusoidal motion for estimated MCE accelerogram was worked out to be 28.5 cycles. This motion was applied with frequencies of 5 to 10 cycles per sec. It was found that for both the materials for core as well as shell, there was no development of excess pore pressure for the design table motion. Even upto 100 cycles of motion there was no development of excess pore water pressure in core and only marginal development in case of shell material. The conclusion was that no significant loss of strength would take place for either material under MCE condition.

5.4 Stability Analysis

5.4.1 Slope Stability

Before carrying out detailed dynamic stability analysis, as stated above the stability of the dam slope has been checked by the pseudo static approach for seismic coefficient of 0.12g as recommended by the Standing Committee for design seismic coefficient.

Minimum factor of safety obtained for the various conditions of testing are given.

Sl. No.	Slope	Testing Condition	Factor of Safety			
			Fellenius Method		Bishop's Method	
			Normal	With Earthquake	Normal	With Earthquake
1.	Upstream	End of Construction	1.953	1.405	-	-
2.	Upstream	Drawdown	1.826	-	1.993	-
3.	Upstream	Reservoir Full	1.875	1.163	2.130	1.258
4.	Downstream	Steady Seepage/ End of Construction	1.562	1.164	-	-

5.4.2 **Dynamic Stability Analysis**

Dynamic stability analysis has been carried out using following approaches :

i) Plastic Displacement Analysis.

ii) Dynamic Stress Analysis by Finite Element Method.

5.4.2.1 **Plastic Displacement Analysis**

This analysis has been carried out using approach suggested by Goodman and Seed (1966) to assess the deformation of a slope of cohesionless materials. This approach essentially assumes that displacement would occur when the response acceleration exceeds a certain critical value called yield acceleration. Yield acceleration is defined as the acceleration at which the factor of safety would be unity and can, therefore, be easily worked out using conventional limit equilibrium approaches.

For working out the plastic displacement for the dam, two approaches were used. Firstly the dam was assumed to behave as a rigid structure i.e. it was assumed that acceleration time history at each point in the dam body would be same as that of ground motion. The yield acceleration corresponding to the critical wedges of upstream and downstream slopes worked out to 0.16 g and 0.21g respectively. The plastic displacement for upstream and downstream slopes worked out to 48.25 cms and 17.37 cms respectively. In the second case the dam was assumed as non-rigid structure through which the ground motion gets amplified depending upon the damping characteristics of the material. In this case the permanent crest settlement was found to be of the order of 52 cms. These settlements are much less than available component of 2.5 m in the total free board of 9.5 metres provided for Tehri dam.

5.4.2.2 <u>Dynamic Stress Analysis by Finite Element Method</u>

A linear gravity turn-on two dimensional finite element analysis has been carried out both for static and dynamic conditions. Loading due to self weight, water pressure, uplift and simultaneous application of horizontal and vertical earthquake excitation were considered in the analysis. The self weight was worked out by evaluating the equivalent nodal loads due to gravity loading. The water pressure was assumed to be acting normally on the upstream face of the inclined core. Submerged weights were considered for the upstream shell below the water level, saturated weight for the core below pheratic surface and moist weight in the rest of the dam section.

The properties of the material adopted in analysis are as follows :

Sl.No.	Material	G_o (Kg/cm^2)	m	ϕ (Degrees)	μ	K_o
1.	Shell	600	0.5	38	0.39	0.64
2.	Core	200	0.3	27	0.36	0.56

Where , $G = G_o \; (\sigma m)^m$

G_o = Shear modulus at confining pressure of $1 \; kg/cm^2$

m = constant

K_o = coefficient soil pressure at rest

μ = poisson ratio

Model analysis was carried out for dynamic analysis, and time periods and mode participation factor upto six modes were worked out.

At the dam site the river flows with in a curved alignment. In order to see the three dimensional effect of the valley on the stability of the dam, two sections of the dam, one in the river bed and the other on the right abutment were analysed. On account of the curvature in the river, the two sections are geometrically quite dissimilar. At the river section (Section A), height is 239 m at the centre of the core, but at a short distance d/s of the core, the ground level rises up, so that downstream limb of the dam is unusually short. The abutment section (Section B) has a height of only 111 m at the core, has a short upstream slope but a long d/s slope. The finite element idealisation for the two sections is shown in Fig. 5 & 6.

5.4.2.3 **Results of Analysis**

a) **Maximum Stresses :**

Section A

Under the static loading, a maximum tension of 33 t/m2 (tension is positive) in element 116 and a maximum compression of 572 t/m2 (compression is negative) in element 119 is indicated.

Under the MCE conditions, a maximum tension of 105 t/m2 (tension is positive) in element 116 and maximum compression of - 671 t/m2 (compression is negative) in element 119 are indicated.

Section B

Under the static loading, a maximum tension of 26.9 t/m2 (tension is positive) in element 61 and a maximum compression of - 349 t/m2 (compression is negative) in element 54 is indicated.

Under MCE conditions, a maximum tension of 70 t/m2 in element 61 and a maximum compression of 384 t/m2 in element 54 are indicated.

(b) **Static Deflection Along The Dam Axis :**

Under the static loading, the maximum horizontal deflection of 15.4 cm and a maximum vertical deflection i.e. settlement of 68.4 cm were indicated along the axis of Section A. For the Section B, the maximum horizontal deflection of 13.3 cm and maximum vertical deflection i.e. settlement of 27.7 cm were indicated.

(c) **Maximum Dynamic Displacement :**

For Section A, under dynamic loading, the maximum dynamic nodal displacement is 36.2 cm horizontally & 12.7 cm vertically, relative to the ground. For Section B, the estimated maximum dynamic nodal displacement relative to the ground for Section B is 25.1 cm horizontally and 7.0 cm vertically.

5.4.2.4 **Conclusions :**

It is seen that the tension calculated, occur only in shell portion and are for very short time intervals. Since shell material cannot sustain any tension in actual practice, there would be re-distribution of load in the adjacent element. No tensions are indicated in the core of the dam. Considering the above facts, it is concluded that the dam is safe from seismic consideration.

6.0 STUDIES BY SOVIET CONSULTANTS

6.1 Site Specific Assessment of Seismicity

6.1.1 The Soviet Consultants carried out fresh studies for site specific assessment of seismicity. For this purpose, following studies were carried out by them.

a) All the existing available data about seismotectonics of Himalayas available with the National Organisation/Institutes of India like GSI, IMD, NGRI, DEE (UOR), Wadia Institute of Himalayan Geology and other published literature was studied and collated.

b) The above-mentioned information base was further strengthened by studies of satellite imageries of the region.

c) Paleo-seismological assessments were carried out by field studies.

d) Instrumental seismic microzoning studies were carried out to study the variation of the seismic parameters of seismic effects along the height of the canyon.

6.1.2 The conclusions of the above studies are set out in brief in the report " Conclusions of Soviet Consultants on Tehri Dam Area Seismicity and recommendations on selecting ground motion for Tehri Dam " copy of which has already been given to Experts Group. Main conclusion is as under :

" With the information available, the estimates of the

Tehri Dam area seismicity is optimum and conservative. Taking into account that the Tehri project structures will be located within a single tectonic block and the peak ground acceleration at the middle part of the canyon i.e.at dam crest level will not exceed 0.5 g, the seismological and seismotectonic conditions of the area are suitable for high dam construction ".

6.1.3 The Soviet Seismologists considered 15 source zones which can generate earthquake effecting in Tehri Dam as given in Table - 2.

Table 3 lists the source zones which can generate the strongest earthquake at the dam site. This table does not contain the full list of tectonic faults and source zones but only those which are most important from the view point of the seismic effect at the dam site. For working out the main parameters of accelerogram, following factors were determined for the various source zones.

1. Maximum Peak Ground Acceleration.
2. Pre-dominant period of Peak Ground Acceleration.
3. Duration of Ground Acceleration.
4. Acceleration duration and acceleration level of 0.3 of maximum acceleration.
5. Acceleration duration and acceleration level of 0.5 of maximum acceleration.

TABLE-2

SEISMOGENERATING ZONES OF TEHRI HPC REGION

Sl. No.	The Name of Seismogenerating Zone or of it's Separate Section	Magnitude of Strongest Recorded Earthquake	M max	Most Probable Depth (km)	Most Probable Type of Source Movement (km)	Distance from Dam Site (Km)	Notice
1.	Foothill Zone Kangra Section	8.0	8.0	20	Reverse	250	
2.	Foothill Zone Nahan-Dehradun Section	8.0	8.0	20	Reverse	40	
3.	Foothill Zone Ganga-Kosi Section	8.0	8.0	20	Reverse	50	
4.	MCT Zone Yamuna Section	-	7.0	15-20	Thrust	50-70	
5.	MCT Zone Mandakini Section	-	7.0-7.5	15-20	Thrust	40-60	
6.	East-Kangra Zone	7.0	7.5	15-20	Tangential	160-180	
7.	Ganga-Parola Zone	5.9	7.0	15-20	Tangential	25	
8.	Nainital-Uttar-Kashi Zone	-	7.0	15-20	Tangential	25	
9.	Pindar Zone	6.6	7.0	15-20	Tangential	100	
10.	Kinnaur Zone	6.2	7.0	20-30	Normal	130	
11.	Siansu-Lambgaon Zone	5.3	6.0	15-20	Oblique-shift	15	
12.	Alaknanda Zone	5.0	6.0-6.5	15-20	Oblique-shift	30	
13.	Srinagar Zone	4.5	6.0-6.5	15-20	Reverse	5-7	Dam site is in the down thrown block
14.	Nayar Zone	-	6.0-6.5	15-20	Reverse	20	
15.	Local Zones	4.8	5.0-5.5	10-20	Different	10	

TABLE - 3

CHARACTERISTICS OF SEISMIC SOURCE ZONES AND DESIGN GROUND MOTIONS AT TEHRI DAM AREA

Parameters	Units	Seismic Source Zone						
		MCT	MBF (Fragments) Giri-Yamuna	MBF (Fragments) Ramganga Kosi	Srinagar	Ganga-Parola	Chom-Balia-na(Sia-nsu-Lambgaon	Minor Linea-ment
Magnitude	M	7.5	8.0	8.0	6.5	7.0	6.5	5.0-5.5
Source Depth	h,km	15	20	20	15	15	15	9
Distance (minimum)	r,km	40	40	50	5	25	25	2-5
Mechanism	-	thrust	thrust	thrust	reverse fault	strike-slip-reverse faults	strike-slip-reverse faults	strike-slip-reverse faults
Recommended Parameters								
(i) Peak ground horizontal acceleration (g) at mid level of the canyon	A_{max} g	0.25	0.3	0.3	0.5	0.15	0.15	0.25-0.35
(ii) Predominant period range of ground motion	T, sec	0.26-0.39	0.25-0.48	0.30-0.50	0.18-0.40	0.22-0.48	0.18-0.40	0.16-0.28

acceleration time history								
Oscillation duration 0.5	Sec	21-57	24-49	27-55	9-18	14-27	11-22	7-[illegible]
Oscillation duration 0.3	Sec	7-12	9-19	9-19	3.5-7.5	3.5-7	2.5-6	2.5-3

NOTE :

0.5 - Oscillation duration on the level of 0.5 of A_{max}.

0.3 - Oscillation duration on the level of 0.3 of A_{max}.

6.1.4 Based on these estimations, the Soviet Consultants have worked out 10 accelerograms along with the response spectra at 5% of critical damping. After reviewing these response spectra two worst response spectra were chosen with PGA of 0.5 g and 0.4 g respectively for carrying out actual analysis. The response spectra and time histories are shown in Fig. 7 & 8.

6.1.5 Seismic microzoning studies have been carried out for the first time in the country and have given very unique results. These studies have established that at Tehri gorge site, the acceleration at top of the canyon is twice that at the middle of the canyon and the acceleration at the bottom of the canyon is 2/3 of that observed at the middle of the canyon. This brings to focus the important point that while talking about peak ground acceleration, one should also refer to the level to which it is applicable.

6.2 Dynamic Parameters for Dam Fill Materials

The materials for the dam viz core, shell and rip-rap were tested in the Soviet laboratory in the large size of dynamic triaxial testing machine 300 mm dia and 600 mm high.

6.2.1 Core Material

6.2.1.1 For the core material both the main material to be placed at OMC as well as the more plastic material to be placed at +2% OMC along the peripheral zones have been tested. The tests were carried out under consolidated drained condition. Strength properties of the core material are given in Table-4. The bulk modulus (K) and shear modulus (G) were also determined by triaxial tests.

6.2.1.2 Dynamic testing on the core material was not carried out because based on their previous experience the Soviet Consultants consider that no liquefaction or build up pore pressure is possible in the Tehri core material under seismic loading. This is also confirmed by the studies carried out by DEE,UOR.

6.2.2 Coarse Gravel Material

6.2.2.1 Coarse gravel material were tested by modeling method. On the gravel materials tests were carried out by compacting these to high density 2.28 gm/cm^3 and 2.38 gm/cm^3 . Rip-rap material was tested at density of 1.7 and 1.8 gm/cm^3 . The strength properties of the tested materials are given in Table-5. Relationships were established for finding out the values of bulk modulus (K) and shear modulus (G).

TABLE - 4

STRENGTH PROPERTIES OF MATERIAL FROM KOTI BORROW

Sl. No.	Material State	Strength tg Ø	Properties Ø	C, MPa
	Material for dam core m<4.75 = 40%			
1.	Material at optimum water content W=0.08, ρ_d= 2.07 g/cm^3, W < 4.75 = 0.13	0.57	29.0	0.084
2.	Water saturated material W=0.111, ρ_d= 2.07 g/cm^3 W <4.75 = 0.183	0.54	28.3	0.033
3.	Material at optimum water content (W=0.08, ρ_d =2.07 g/cm^3) saturation (W=0.11) was done after stabilization of strains due to hydrostatic compression	0.54	28.3	0.056
4.	Material for peripheral zone (m < 4.75 = 80%)	0.49	26.0	0.044
	Material : W=0.146, ρ_d = 1.89 g/cm^3 W< 4.75 = 0.17			

(*) W < 4.75 - Water content of the fine grained material.

The modulus of volumetric strain (K) and shear modulus (G) determined by the triaxial compression tests were used as deformative characteristics in the strain-stress analysis of the dam.

TABLE - 5

STRENGTH PROPERTIES OF COARSE GRAINED MATERIALS

Material	Dry soil density	Range of normal stresses		Strength properties acc. to Mohr.		
	ρ_d, t/m³	σ_n , MPa		Cm, Mpa	tg ϕ_m	ϕ°_m
Gravel	2.28	<	0.26	0	1.015	45
		>	0.26	0.07	0.781	38
	2.38	<	0.43	0	1.20	50
		>	0.43	0.13	0.908	42.2
Random Quartzite rock	1.70	<	0.13	0	1.06	47
		>	0.13	0.05	0.7	35
Random Quartzite rock	1.80	<	0.175	0	1.134	48.6
		>	0.175	0.07	0.78	38

6.2.2.2 During triaxial tests, dynamic modulus of elasticity and damping (δ) were also determined. Relationships were established for determination of these values for all the fill materials, indicating the values for various constants.

In cyclic loading test the samples were first loaded in steps to desired static loading then axial load was decreased by the value in slight excess of the amplitude of cyclic load to be applied. The cyclic loading was continued till no further deformation were observed in the sample. The results of the cyclic test were described in the graphical form indicating the secondary visco-plastic shear and volumetric strain. These curves were used to determine parameters of secondary visco-plasticity which are used in the stress-strain analysis of dam..lm8

6.3 Non-Linear Dynamic Analysis

A state-of-the-art non-linear, sequential (static as well as dynamic) stress analysis by Finite Difference Method using Elasto-Plastic model has been carried out by Scientific Research Centre of Hydroproject Institute, Moscow. This analysis takes into account the stress dependent properties of the material, the schedule of raising of the dam, the schedule of reservoir filling, the consolidation of clay core and development of construction pore pressures, the effect of permeabilities of various materials in the development of pore pressures both during static as well as dynamic loading and it finds out the zones of sustained plastic strains representing failure.

As stated earlier the Soviet Consultant tested the dam for two accelerograms with worst response spectra - one for a 6.5 mag earthquake originating from Srinagar thrust with a peak ground acceleration of 0.5 g and the other for an 8.0 mag earthquake originating from MBF (Giri, Yamuna section) with a peak ground acceleration of 0.4 g. These accelerograms were for the mid level of the canyon, the microzoning studies revealed that at the bottom of the canyon, their values would be 1.5 times less. But in the actual analysis, accelerograms with PGA of 0.5 g and 0.4 g were applied at the base of the dam. This in fact means that dam has been tested for much severe strong motion - PGA of 0.75 g and 0.6 g at the level of mid canyon (which is the normal practice).

6.3.1 Elasto-Plastic Analysis - Optimisation of Geometry of Dam Zones

Elasto-Plastic analysis was carried out to optimise the designed dam section and the core geometry which would ensure stability of the dam and its safe behaviour both under static condition as well as under dynamic loading. Studies were also carried out to determine whether there was need to replace gravel shell in the top 80 m portion by blasted rock fill which had earlier been recommended by the Soviet Consultants based on their general experience. Nine alternatives were studied which are listed in the Table-6.

In the analysis, it was assumed that dam would be built in 7 stages and construction would take 7 years. The first stage comprised of construction of

80 m high upstream coffer dam which forms the upstream toe of the embankment. In the 2nd stage, the coffer dam will be raised to 106 m height with water level filling upto 60 m height. From 3rd stage onward upto 7 stages the dam embankment will be built in horizontal layers reaching top of the layer at the end of 7 years. It was assumed that after completion of construction, the dam would be filled upto its FRL over a period of two years.

TABLE - 6

LIST OF ALTERNATIVE DESIGN CASES

Alternative	Design Feature
1	Design Section - inclined core with 80 m high rockfill surcharge (core shown in red).
1a	Design Section - inclined core with 20 m high rockfill surcharge (core shown in red).
1b	Design Section - inclined core with 20 m high rockfill surcharge (core shown in red). Seismic loading is reduced by a factor of 1.5.
2	Arch-shaped core with 80 m high rockfill surcharge (core shown in green).
2a	Arch-shaped core with 80 m high rockfill (core shown in broken black line).
2b	Arch-shaped core with 20 m high rockfill surcharge (core shown in broken black line).
3	Alternative core design with 20 m high rockfill surcharge (core shown in bold black line).
4	Alternative core design with 20 m high rockfill surcharge (core shown in bold black line). Core composed of water saturated loam.
5	Alternative design with central vertical core (core shown in blue line).

Fig.9 shows the finite difference grid with various alternate position of the core studied and the check points at which stresses, displacements and accelerations are studied.

With the help of finite difference method, stress tensor components, pore pressures, vertical and horizontal displacements, contours of volumetric strains in the dam body, contours of ratio of shear strains to ultimate allowable shear strains were determined at the end of construction condition and reservoir filling. Then earthquake loading was applied and change in pore pressures, shear strains, and horizontal displacement and ratio of shear strains to ultimate shear strains (factor of safety) determined. Occurrence of non-damping (i.e. sustained) plastic strains defined the existence of plastic failure at a point. However, in this context it is to be kept in mind that local failure of soil in some points of the dam is not an indication that the structure is endangered as a whole. The fact is only indicative of loss of shear strength at those points. If the neighboring points of soil mass did not reach the limit state, the growth of plastic strains would come to a halt and no failure of the structure will occur. Only in case when a whole zone having a free surface is reaching the limit state, the structure can be stated to have failed.

First of all, alternate 1 (upstream inclined core of 0.3 H thickness with its base flared to 0.5 H thickness with the help of upstream inclined slope of 1:1) and alternate 5 (central vertical core) were studied. It was seen that under dynamic loading, plastic zones were formed at the upstream face of the dam with alternative 1 whereas alternate 5 was safe against both the accelerograms. The reason for this behaviour was analysed as under-consolidation of u/s shells due to presence of inclined core which resulted in compaction and hence development of excess pore pressures on application of dynamic loading. On the other hand in static condition, stress transfer from core to shell was highly pronounced in case of Central core as compared to inclined core. Therefore, optimisation studies were carried out to determine the most optimal geometry of the core which would lead neither to formation of plastic zones under dynamic load nor to excessive transfer of stress from core to shell leading to possibility of hydraulic fracture. Three additional positions of core as represented by alternative 2, 2a and 3 were studied. It was seen that non-damping plastic zones were not formed in any of these alternatives and stress transfer was also reduced as compared to central core. Stress condition in these 3 alternatives were similar and alternative 3 has accordingly been adopted keeping in view the site topography and ease of construction.

Comparative study carried out in alternative 2a and 2b with and without zone of blasted rock has established that there is no need to replace the gravel shell with the blasted rock.

It is to be noted that the Soviet Seismologists had recommended the accelerograms for the mid level of the canyon, whereas these were applied at the base of the canyon. Thus, the dam is found to be safe for a seismic loading 1.5 times the recommended design loading by the Soviet Consultants.

7.0 CONCLUSIONS FROM STUDIES BY U.O.R And SOVIET CONSULTANTS

7.1 Based on the detailed studies carried out independently by Department of Earthquake Engineering, UOR and Hydroproject Institute, Moscow for site specific assessment of possible seismogenerating zones, estimates have been made with regard to maximum possible earthquake which can be generated by these zones and Effective Peak Ground

Acceleration (EPGA)/ Peak Ground Acceleration (PGA)which can result from these earthquakes. Table-7 gives a comparison of assessments made by DEE and Soviet Consultants in this regard.

7.2 Studies for seismic stability of dam has been carried out by two independent organisations viz Deptt.of Earthquake Engineering, University of Roorkee and Hydroproject Institute, Moscow, who have been supported in their studies by inputs from the Geological Survey of India (GSI) , Wadia Institute of Himalayan Geology, India Meteorological Department, National Geophysical Research Institute, Department of Earth Sciences, University of Roorkee, Roorkee and Central Water Commission. In the process, stability of dam has been checked for three accelerograms and by various methods.

7.3 Finite Element Analysis carried out by DEE, UOR has established that tensions are not created in the core and that tensions created in the shells are of small magnitude and transitory in nature. Three dimensional nature of the problem has been taken care of by studying two real sections which are geometrically very dissimilar. Plastic dynamic displacement method has established that due to earthquake loading, the crest settlement is very small and is of magnitude 52 cms, which is very small as compared to total free board of 9.5 m.

7.4 Elasto-Plastic analysis carried out by Soviet Consultant has helped in refining the geometry of the core. With the selected geometry, non-damping plastic zones are not formed. Maximum settlement due to earthquake works out to 55 cms which closely tallies with that calculated by displacement analysis.

TABLE - 7
SEISMOGENERATING ZONES OF TEHRI HPC REGION

1. **Indian Studies (Earthquake Engineering Deptt, UOR)**

Sl. No.	Seismic Source	Possible Earthquake Magnitude	Focal Depth (km)	Hypocentral Distance (km)	Type of Fault	EPGA
1.	Srinagar Thrust	6.5	20	26	Reverse	0.19 g
2.	M.C.T	7.0	20	37	Thrust	0.20 g
3.	M.B.F	7.0	20	27	Thrust	0.25 g
4.	Himalayan Frontal Thrust	7.25	20	48	Reverse	0.19 g

2. **Soviet Studies (Hydroproject Institute , Moscow)**

Sl. No.	Seismic Source	Possible Earthquake Magnitude	Focal Depth (km)	Distance (km)	Type of Fault	PGA (at mid canyon level)
1.	M.C.T	7.5	15	40	Thrust	0.25 g
2.	M.B.F (Fragments)					
	a) Giri-Yamuna Zone	8.0	20	40	Thrust	0.30 g
	b) Ramganga Kosi	8.0	20	50	Thrust	0.30 g
3.	Srinagar Thrust	6.5	15	5	Reverse	0.50 g
4.	Ganga-Parola	7.0	15	25	Oblique, shift	0.15 g
5.	Sisanu-Lamb-gaon Zone	6.5	15	25	Oblique, shift	0.15 g
6.	Minor Lineaments	5.0-5.5	09	2-5	Reverses shift	0.25 g 0.35 g

8.0 DYNAMIC STABILITY ANALYSIS FOR TEHRI DAM - APPLYING ACCELEROGRAM OF GAZLI EARTHQUAKE

8.1 In 1992, in context of concerns raised about safety of Tehri dam in event of occurrence of a big earthquake, plea was made by one member of High Level Committee which had gone into safety aspect of Tehri dam earlier in 1990, that Tehri dam section should be tested for the actual accelerogram of Gazli Earthquake which occurred in USSR in 1976 and where an acceleration of more than 1 g was recorded. Since as per his view acceleration of this order could occur in event of occurrence of a major earthquake in Tehri region. Accordingly seismic stability analysis was got carried out by THDC, at Hydro-Project Institute, Moscow using actual accelerogram of Gazli earthquake. This earthquake occurred in flat topography at Karakyr and the recording instrument was stationed right over the epicentre. As the epicentral distance was zero, very high peak accelerations were recorded. The vertical peak acceleration was 1.36 g while the horizontal peak ground acceleration recorded was 0.72 g.

8.2 For assessment of seismic stability, two studies were carried out:

i) Assessment of dam slope seismic stability using Gazli records, considering non-linear elastic material behaviour.

ii) Study of stress-strain state and assessment of seismic stability using Gazli accelerogram, considering elasto-plastic model.

Since Gazli earthquake occurred in flat terrain, therefore for carrying studies for Tehri, canyon effect has to be taken into account. However, in order to study the effect of worst seismic situation, analysis was also carried out neglecting the canyon effect.

8.3 The conclusions from these studies are :

i) Minimum factors of safety in slope stability, considering non-linear elastic behaviour of soils are in the range of 1.38 - 1.5. Even after ignoring canyon effect, minimum factors of safety are 1.05 - 1.27, as against requirement of 1.0 in I.S.Code.

ii) The analysis of dam, considering elasto-plastic behaviour of soil materials, indicated that even after termination of seismic loading, displacement and deformation get stabilised at every point in every considered condition. This assures that even after the earthquake event like Gazli, dam would be a load bearing structure.

iii) The maximum residual displacement even in extreme conditions in lower part of dam will be 0.9 m, while it would be 0.5 m at dam crest. The maximum vertical settlement will not exceed 0.42 m.

The studies clearly bring out that Tehri dam is seismically stable under loading of Gazli earthquake accelerograms.

9.0 DEFENSIVE MEASURES INCORPORATED IN DESIGN OF TEHRI DAM

In context of evaluation of seismic risk, it may be further pointed out that to provide maximum assurance of Safety, dam has been designed adopting most stringent design criteria, incorporating certain features which would ensure its safety in event of any major seismic event. These are :

i) The section adopted for Tehri dam has been generously proportioned with u/s slope of 2.5 : 1 and d/s slope of 2.0 : 1. As against this some recent dams built/planned in region of very high seismicity, for example Pueblo Viejo dam in Guatemala (Height 130 m) and Honda dam in Venezuela (Height 130 m) have u/s slopes of 2.0 : 1 and d/s slopes of 1.75 : 1 respectively. Renowned seismic design expert Prof.

Seed recommended section for the proposed 200 m high Karnali Dam in Nepal, which is to be built in environments very similar to Tehri, with u/s slope of 2.25 : 1 and d/s slope of 1.9 : 1.

ii) To ensure that thinner dam profile at top is able to withstand the high accelerations during a seismic event, a very wide crest - 20 m has been provided. The width of the crest has been further increased to 25 metres at its contact with abutments.

iii) To take care of any settlements or slumping of crest due to a large earthquake, a very liberal free board of 9.5 m (above normal Maximum Reservoir Level) has been provided. Taking into account the height of parapets to be provided for the road at top, this free board would be more than 10 m (many codes provide for accounting of parapet wall height in the provision of free board).

iv) The filter for the dam has been designed on most stringent design criteria. It is capable of preventing migration of finest particles (clay flocks of 0.002 mm size), in event of its cracking and would not permit core erosion.

v) On upstream of core a zone of fine filter has been specified. In event of cracking of core it would get washed into cracks and seal them by choking the water passages.

vi) The dam fill (in shell zone) is to be compacted to almost concrete like density of 2.36 tons/ m (minimum). This density has been actually achieved for the fill placement done for dam during 1989-90 and 1990-91 working season. This is prime defensive measure for ensuring stability of dam during an earthquake. Achievement of such high density, has been possible because of gradation of fill materials available at Tehri which is a mixture of sand, gravels and cobbles. In case of the highest dam in the world-Nurek (300 m high), located in region of very high seismicity in Central Asia, the maximum density which could be achieved was 2.24 - 2.30 tons/m , depending upon grain size distribution of the shell material.

vii) Additional earthquake resistant feature of design is that the dam embankment is founded directly on rock bed after removal of all loose semi-compact overburden. (This work was completed in 1991), thus eliminating any possibility of foundation liquefaction.

viii) A unique feature of design is the provision of galleries at three levels on left and right abutments, galleries in the dam seat below the river bed and inspection and instrumentation galleries running through the dam core, at mid height and near the top. These would provide permanent access to all critical locations in the dam body and enable continuous physical monitoring of dam performances during operation. In event of any distress, timely remedial measures can be taken through these galleries.

10.0 PERFORMANCE RECORD OF EMBANKMENT DAMS DURING EARTHQUAKES

10.1 While on the subject of earthquake-resistant design of Tehri dam, it is pertinent to find out as to how some of the older dams built in regions of high seismicity have actually performed during big earthquakes. Table-8 gives performance record of some such dams constructed in the known highly seismic regions of the World, where earthquakes are a frequent occurrence.

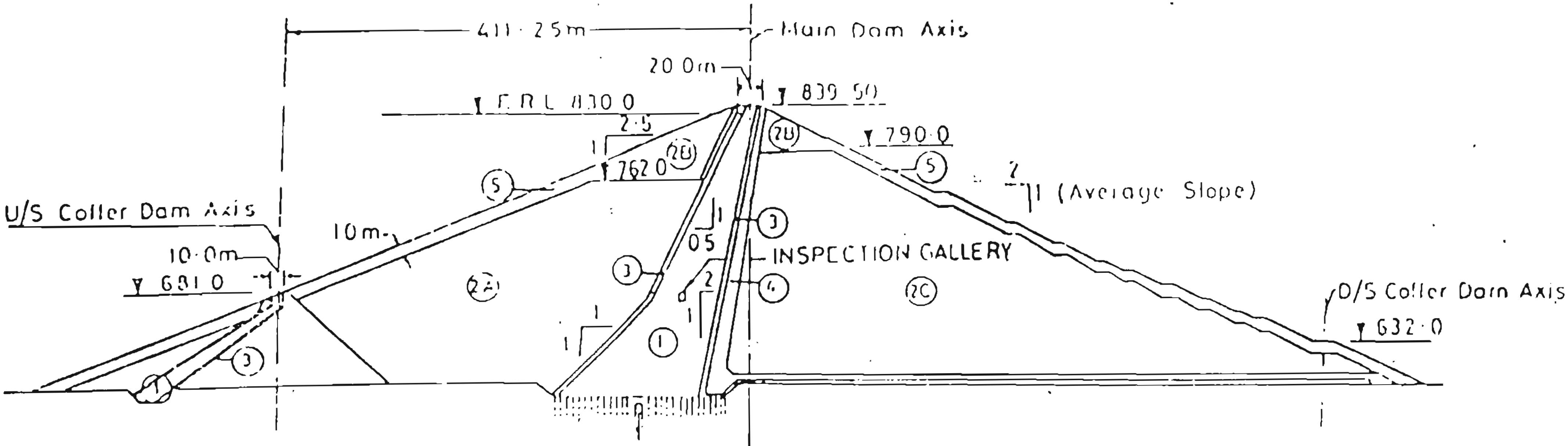
10.2 The experience is that those dams, which were rolled earth/rockfill type, suffered only minor damage, by way of small deformations/settlement, cracks and superficial surface slides, without the water retaining capacity being damaged or compromised. The damages suffered were all within repairable limit. One classic example is of La-Villita and El-Infiernill dams, which were built in 1960s and are founded on 70 m deep alluvium and partly rock and are partly shallow riverbed deposits respectively. **La-Villita dam is located in high-seismicity zone associated with the subduction of** Pacific Ocean Plate under the American Continent. This dam, completed in 1968 has been subjected to five strong earthquakes during 1975-85 period, occurring at epicentral distances of 10 km to 121 km. There are more examples of high dams being successfully built in close vicinity of known active faults. To cite two examples:

i)	Pueblo Viejo Dam, Guatemala	130 m high Rockfill dam	-	Dam is located only 5.5 km from Cuilco-Chixoy-Polocti c (CCP) fault which forms a major tectonic boundary between North American Plate. As per assessment a magnitude 8 seismic event can occur at a distance of 5.5 km. Dam section designed for this strong motion has steeper slopes compared to Tehri.

ii	La-Honda Dam, Uribante Project, Venuzuela	130 m high Earth dam	- Located in highly seismic region. An active fault lies 20 km away from dam site and is capable of generating magintude 8.25 earthquake. Dam design provides for shear displacement of foundation rock of the order of 1 m horizontally and 0.75 m vertically.

10.3 With the advances made in the state-of-the-Art for dam design and construction in the last 3-4 decades, it is perfectly feasible to design and construct fail- safe high dams in most severe seismic environments, within acceptable levels of risks.

(B.L.JATANA)
CONSULTANT



MAIN DAM
TYPICAL SECTION

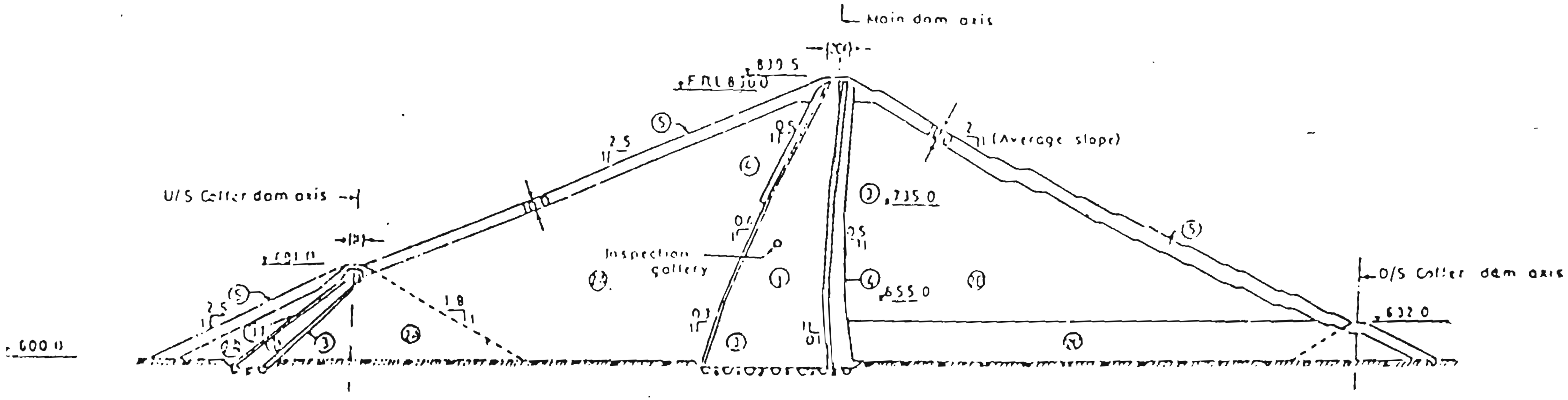
DAM ZONES

1) Impervious blended core
2A) U/S shell zone comprising of terrace gravel material with sand [illegible] not more than 35% & silt particles not exceeding 5%.
3) [illegible] (Exact limits to be defined on detailed analysis)
2C) D/S shell zone comprising of terrace gravel material with sand particles not more than 40% & silt particles not exceeding 5%.
3) Fine filter of fine to medium sand
4) Coarse filter
5) Dumped rip-rap

SCALE
20 0 40 60 100 Metres

FIG 1

130



TYPICAL CROSS SECTION

DAM ZONES

(1) Blanket clay core
(2) Sand gravel shells
(3) Fine filter
(4) Coarse filter
(5) Rip-rap material

Fig. 2

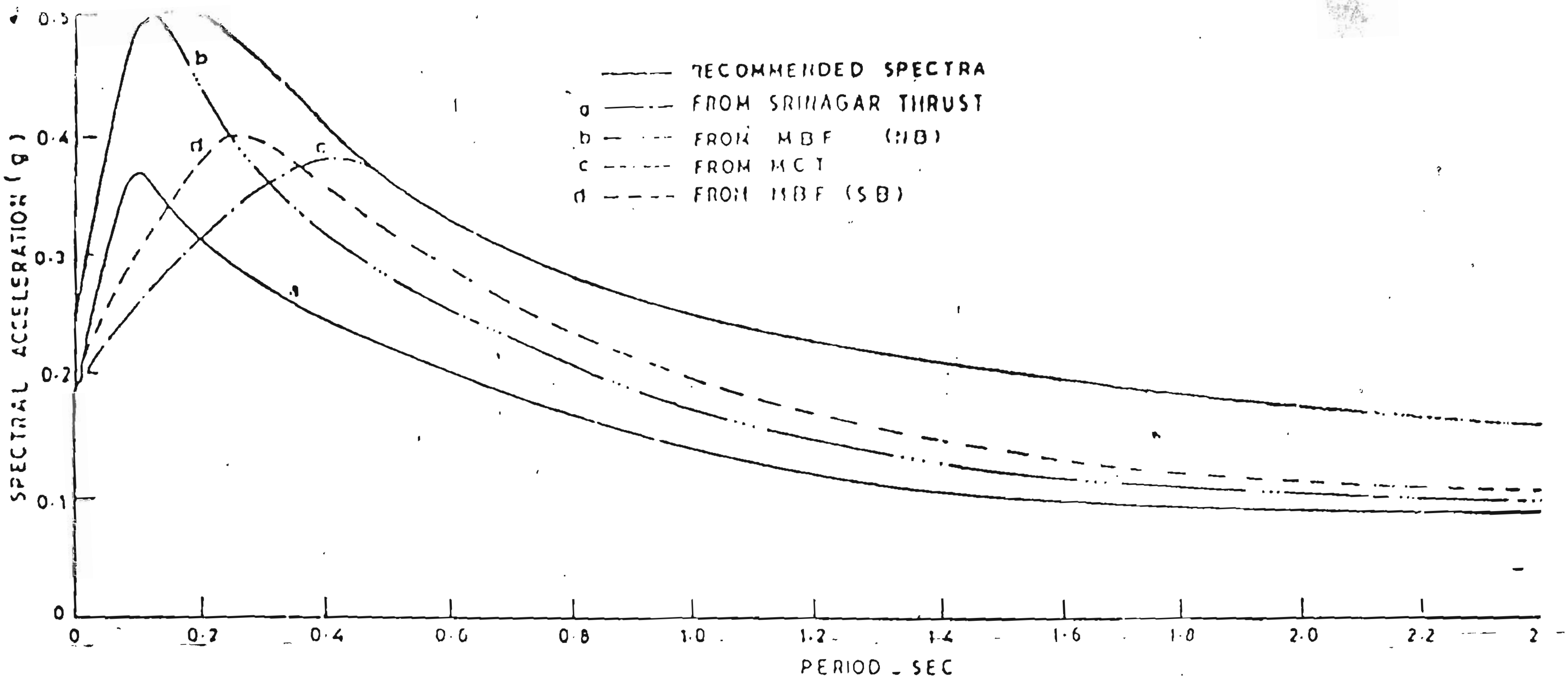


FIG.-3 ACCELERATION SPECTRA FOR MCE FOR TEHRI DAM SITE (DAMPING : 10%) AS RECOMMENDED BY D.E.E., U.O.R.

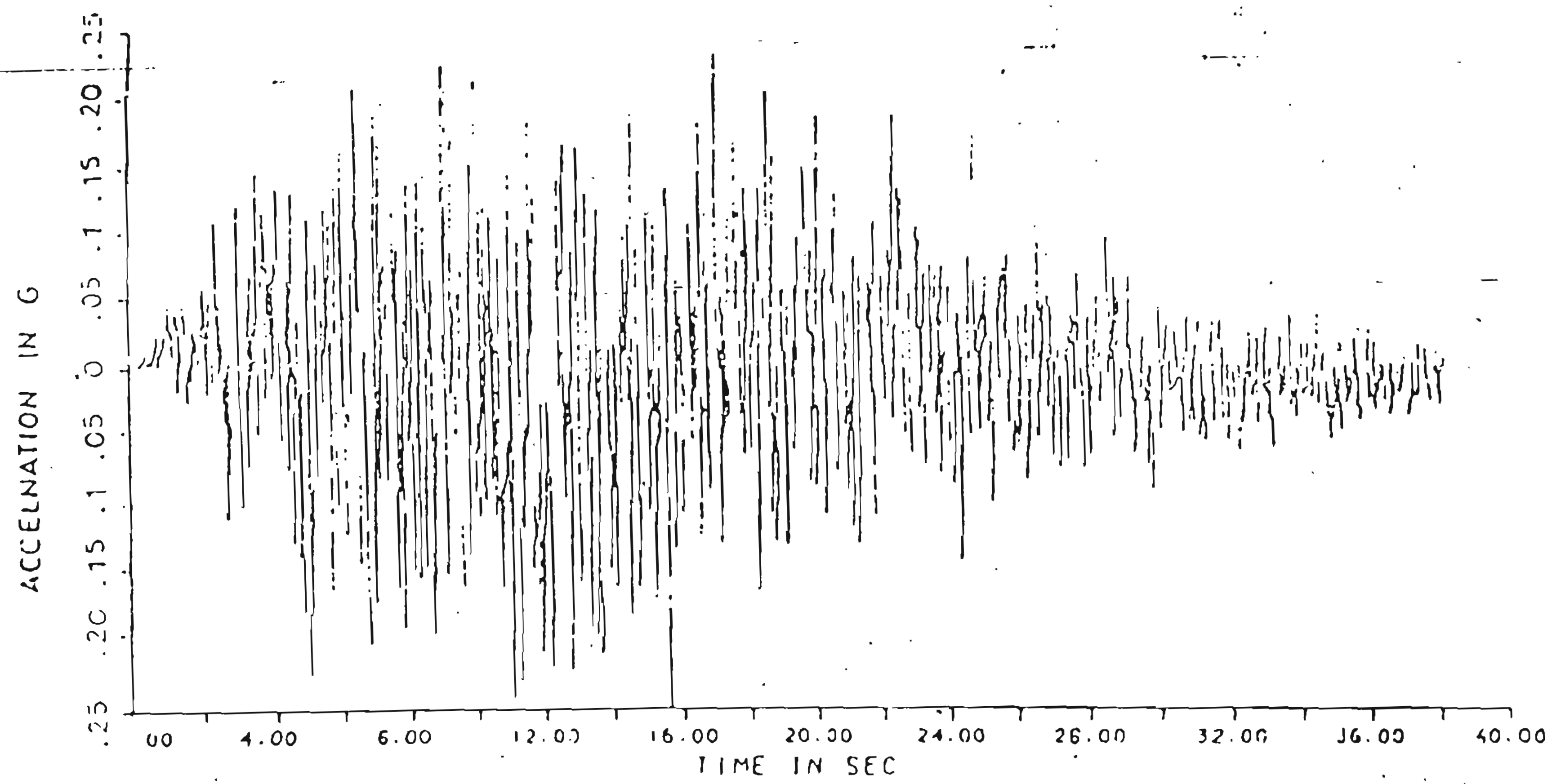


FIG-4 Artificial Earthquake for Tehri site
As recommended by D.E.E.,UOR.

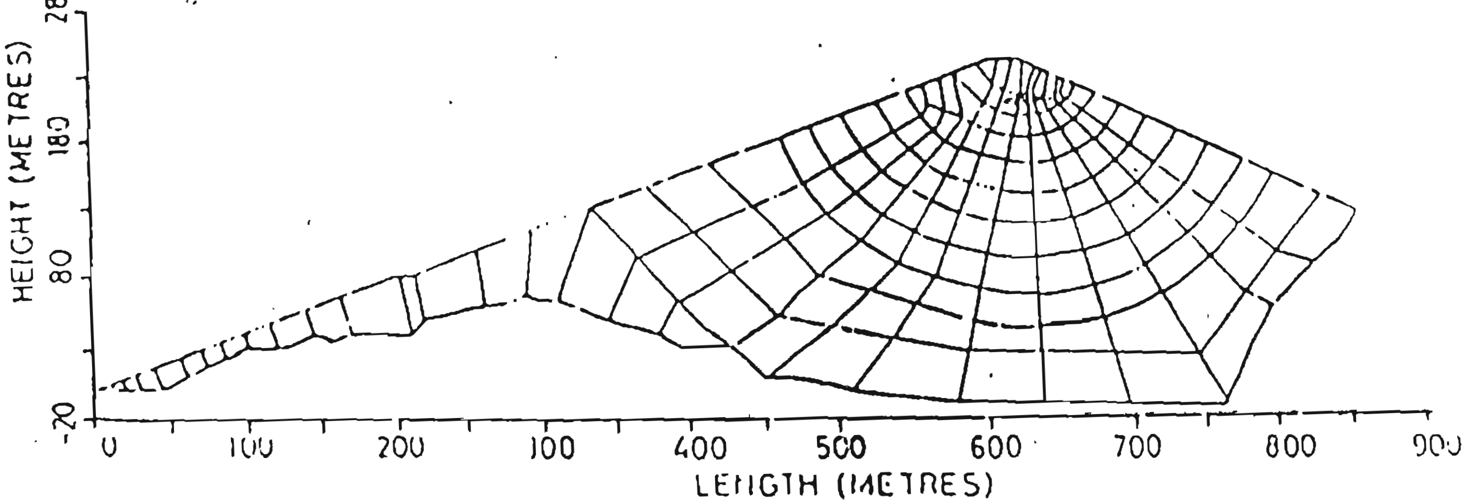


FIG. 5 FINITE ELEMENT IDEALIZATION FOR RIVER BED SECTION
(SECTION-'A')

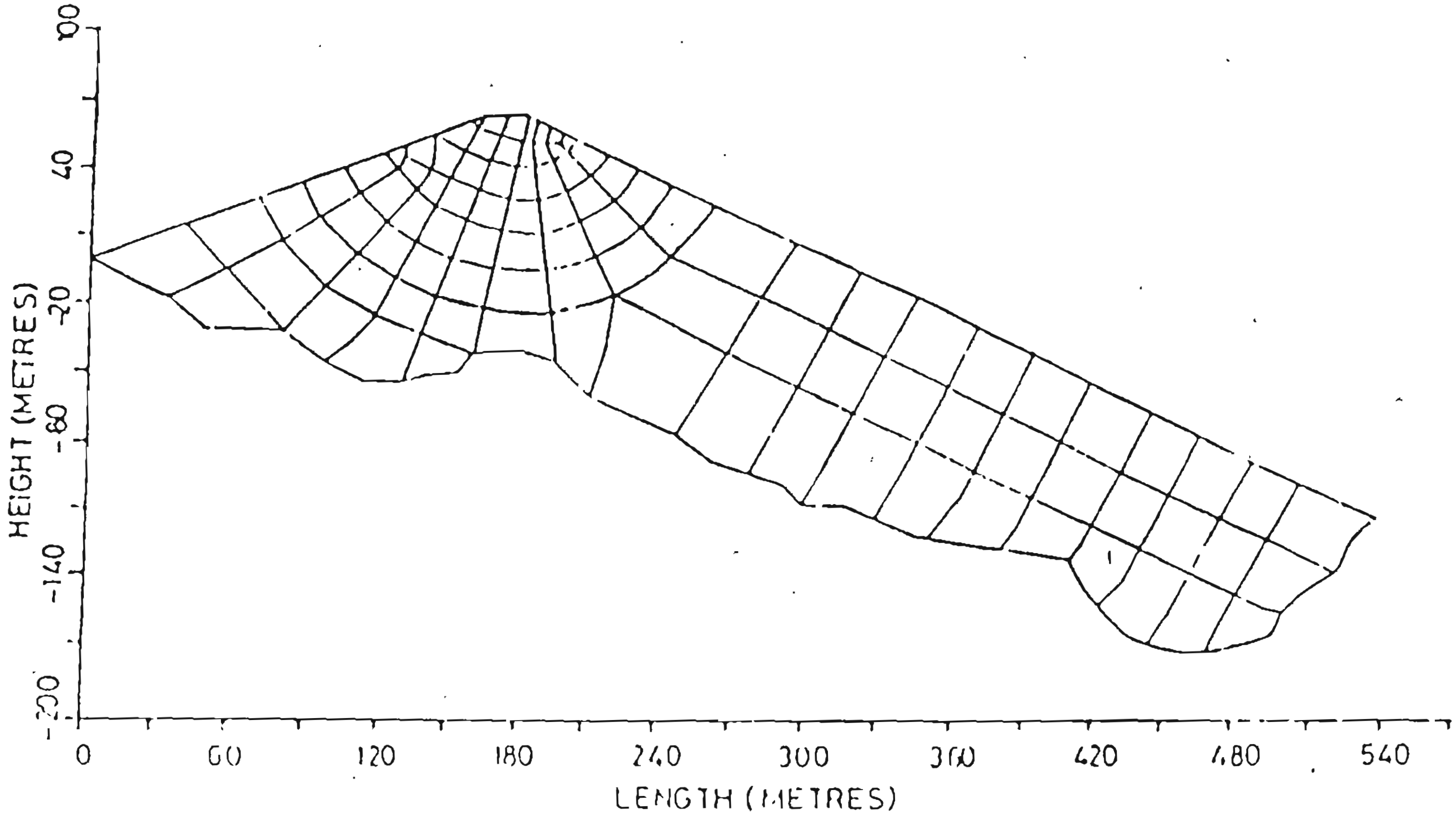


FIG.6 FINITE ELEMENT IDEALIZATION FOR ABUTMENT SECTION
(SECTION-'B')

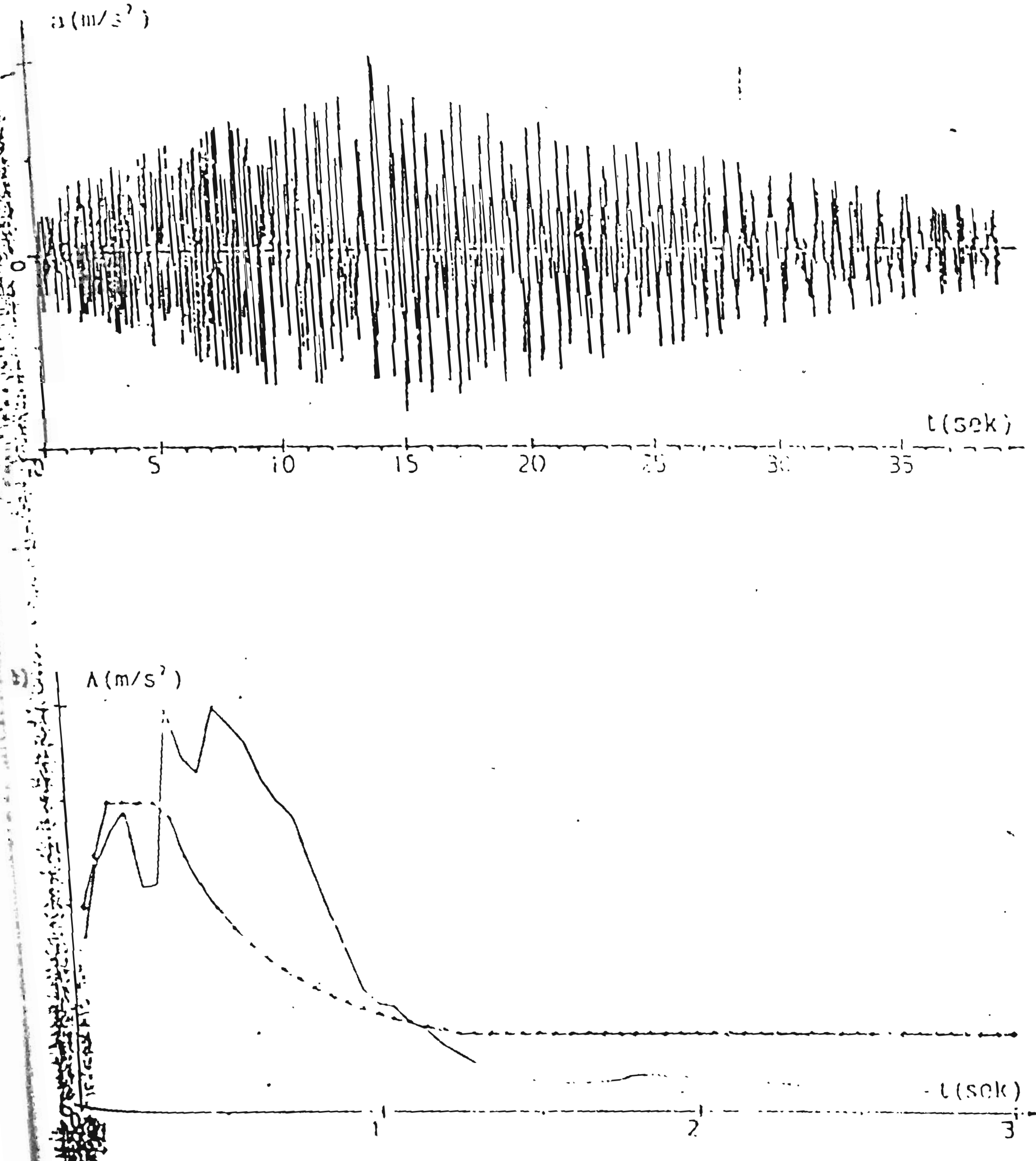


Fig. 7 Standard design synthetic accelerogram TH-MBT 11 (a) and its spectrum (b)

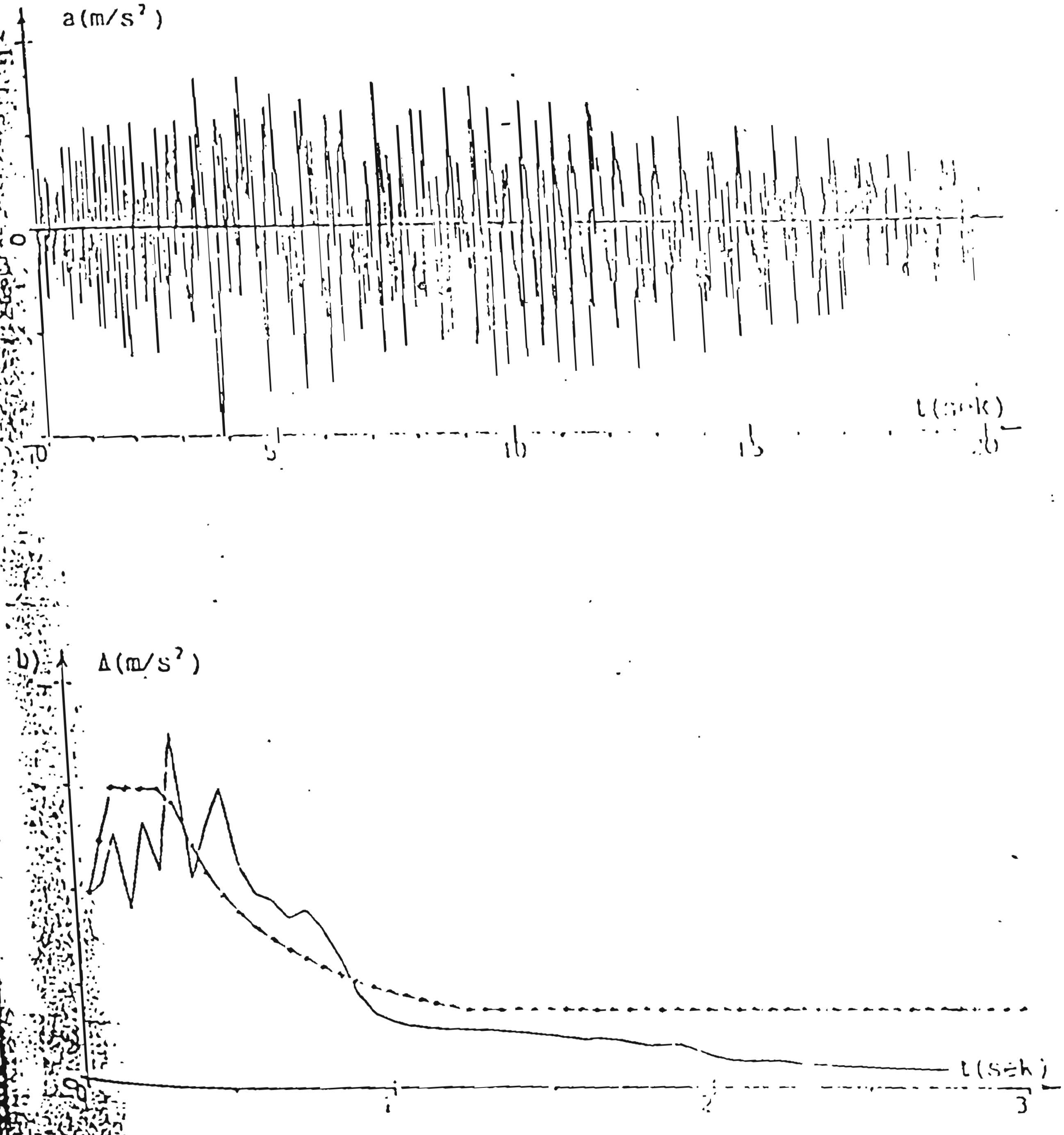
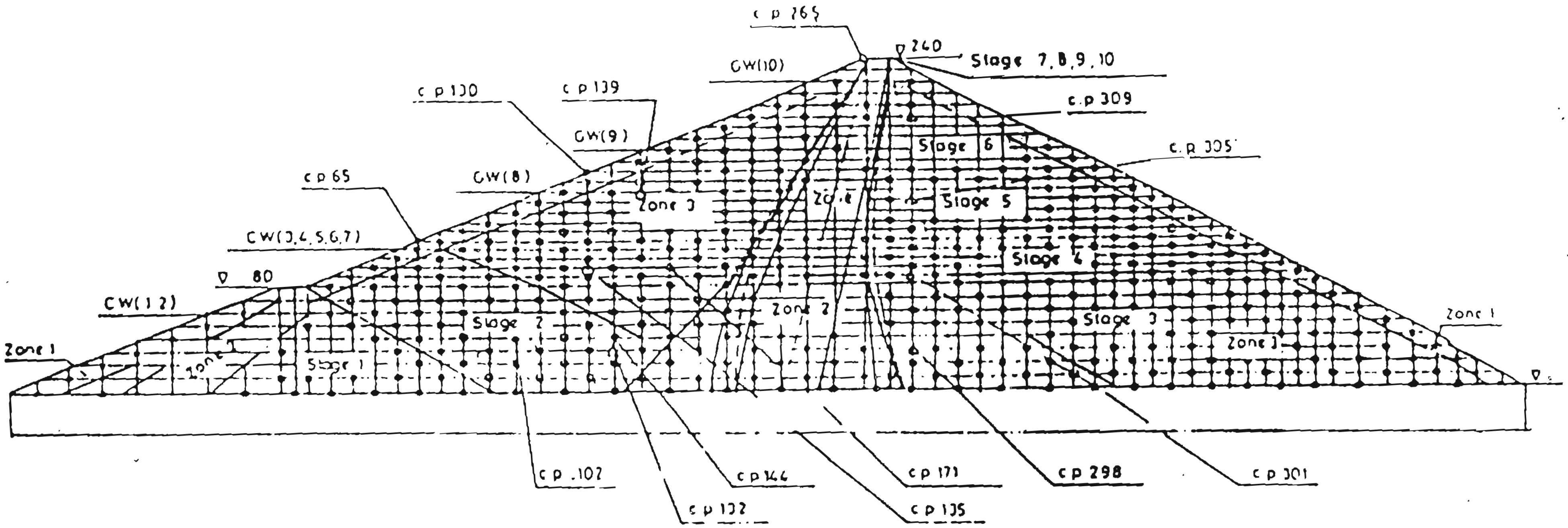


Fig. 8 . Standard design syntetic accelerogram TH [illegible] (a) and its spectrum (b)



Zone 1. Placement of quartzite rock with 1.80 t/m^3 density

Zone 2. Placement of loam with 2.08 t/m^3 density

Zone 3. Placement of gravel-pebble material with 2.38 t/m^3 density

Zone 4. Water-saturated loam with 2.07 t/m^3 density

• 102, 144, 171 - N of check points for stress measurement at earthquake loading

• 65, 130, 265 - N of check points for displacement measrement at earthquake loading

Δ 132, 135, 139, 301, 305, 309 - N of check point for acceleration measrement at earthquake loading

Fig. 9 Finite-Difference Grid and Dam Construction Scheme (alternative 1, 1a, 1b, 2, 2a, 2b, 3, 4)

ANNEXURE-8

EARTHQUAKE ENGINEERING STUDIES EQ 97-09

2D MULTI LIFT NONLINEAR STATIC AND EARTHQUAKE RESPONSE ANALYSES OF TEHRI ROCKFILL DAM

October, 1997

for official use only

DEPARTMENT OF EARTHQUAKE ENGINEERING
UNIVERSITY OF ROORKEE
ROORKEE, 247 667

Preface

The study of 2D non-linear seismic stability of rockfill dam at Tehri, suggested by Expert Group on Safety Aspects of Tehri dam was entrusted to Department of Earthquake Engineering, University of Roorkee by Tehri Hydro Development Corporation Ltd (THDC). The Expert Group on Safety Aspects of Tehri Dam, constituted by Government of India in their meeting on 27.1.97 recommended to evaluate the performance of the Tehri dam under the specified seismic conditions in order to assess the safety of the dam. It was further recommended that scope of the proposed study will be decided in consultation with DEQ, UOR.

Subsequently, Vice Chancellor, UOR, in a meeting on February 25, 1997 where in besides V.C. two other members of the Expert Group, i.e. Prof. R.N Iyenger and Professor Ramesh Chander were also present. The meeting was also attended by Head, DEQ and Professor D.K. Paul, DEQ. The Seismic safety of the Tehri dam was discussed and the following studies were recommended

1. 2D Multi-lift non-linear static analysis.
2. 2D Non-linear dynamic analysis.

The data and necessary information for the analysis of the dam were provided by the THDC. This report briefly describes the 2D multi-lift non-linear static analysis for gravity and water pressure, frequency analysis and earthquake response analysis of the rockfill dam for the postulated ground motion.

The study has been carried out by Dr. D K Paul, Professor, Department of Earthquake Engineering.

October, 1997

3/10/97

(S. Basu)
Professor and Head

CONTENTS

INTRODUCTION

It is important to design dams to safely withstand earthquakes. Apart from stresses due to static loads, the dynamic stresses due to earthquake excitation constitute quite a significant part in the overall stress distribution in the dam. The main objective is to assess the safety of the rockfill dam under the postulated seismic environment.

The proposed rockfill dam at Tehri has a composite section, consisting of shell, rip-rap and core materials. The maximum height of the dam is 260 0 m. The site is in seismically active area and therefore seismic safety of dam is of prime consideration The [illegible] section of the dam has been considered for the seismic safety analysis

The static and the free vibration response analyses of the dam are investigated by finite element method. Effect of variation of material properties with confining pressure is accounted for in the analysis. The natural period of vibration are also studied for the first few modes of vibration

The report describes the theoretical studies carried out to assess the seismic safety of the given section.

OBJECTIVE OF THE STUDY

- A 2D linear one lift static finite element analysis of the dam for self weight and water pressure corresponding full reservoir level is carried out to find out the deformation and stress distribution.

- A 2D plane strain nonlinear multi lift static finite element analysis for the gravity and hydrostatic water pressure to model the construction sequence and the reservoir filling. For the rockfill and clay core materials, the Mohr Coulomb elasto-plastic material model considering the variation of material properties with the confining pressure are to be taken into account.

  The 2D analysis will be carried out for 2D section only corresponding to 'Section B' of DEQ report EQ-89-13.

- To study the free vibration characteristics of the dam, the material properties corresponding to the final stress state obtained from nonlinear multi-lift analysis will be used The frequency of vibration and mode shapes are to be worked out

- To carryout 2D linear dynamic analysis of the dam for the postulated MCE condition and work out the maximum dynamic displacement and acceleration The damping in the first two modes of vibration will be taken as 10%

The modulus of elasticity for 2D elasto-plastic dynamic analysis will be modified in the square of the ratio of the fundamental time period of 3D and 2D free vibration analysis in order to match the fundamental time period of the 2D model of the dam with the 3D fundamental time period. The 3D fundamental time period specified by Expert Group is 1.25 sec.

The site dependent response spectra compatible acceleration time history of ground motion will be taken corresponding to DEQ report EQ-83-04. The spectra and time history of ground motion will be normalised to 0.5g PGA.

- To carryout the 2D nonlinear elasto-plastic dynamic analysis of the dam for the postulated MCE condition and work out the maximum dynamic displacement and acceleration at the crest. The damping in the first two modes of vibration will be taken as 10%.

  The settlement of some key locations will be worked out for the postulated earthquakes. The permanent crest settlement will be worked out at the end of the earthquake excitation.

SECTION OF THE DAM

A 260.0 m high rock fill Tehri dam located at 30° 28' *N* and 78° 30' *E*, near Tehri town is under construction on Bhagirathi river in the lesser Himalaya of the Garhwal Himalaya. The dam site is located near Tehri town at 1.5 km down stream of the confluence of Bhagirathi and Bhilangana rivers.. The dam is located in a narrow gorge, the length of the dam at the crest being 570.0 m. The width at the crest is 20.0 m flared to 25.0 m at abutments. The dam section is composed of central impervious core, transition zone, pervious shells and rip-rap. The dam has an upstream slope of 2.5:1 and down stream slope of 2:1. The core of the dam is moderately inclined and curved on the upstream side. It is a thin core of 0.[illegible]H thickness

and comprises of gravel sand clay mixture obtained by blending.

Since the valley is curved at the dam site and therefore a full cross section for plane strain analysis is not available. The section corresponding to Section B-15 as shown in Fig.1 has been taken for the 2D plane strain analysis. It has a short upstream slope but a long downstream slope.

LOADS ACTING ON THE DAM

Static Loads: The static loads are mainly due to self weight which is worked out by evaluating the equivalent nodal loads. The water pressure is taken as edge load acting on the upstream face of the core In the full reservoir condition the water level is taken upto 830.0 m

Input Earthquake Ground Motion: The Maximum Credible Earthquake (MCE) is taken as the input motion. MCE is the most severe earthquake that may occur once in the life time of the dam. Under its effect the dam may undergo distress in the form of cracks (which could be repaired) without undergoing failure For linear elastic earthquake analysis, 10% damping response spectra as recommended in DEQ report EQ-83-4 has been taken with Peak Ground Acceleration (PGA) pegged to 0.5g.

The motion at the base of the dam is taken as the input motion for this analysis The response spectra compatible earthquake time history is taken as per Ref.1 and shown in Fig.2. Appendix I gives the digitised values of the acceleration time history of ground motion. The vertical ground motion is taken as 2/3 the strength and in phase with the motion in horizontal direction.

MATHEMATICAL MODEL AND DISCRETISATION OF THE SYSTEM

The geometry of the dam and zones identifying the different material properties is shown in Fig 1

Finite Element Discretization Plain strain idealization of the dam has been carried out For the analysis eight noded isoparametric elements nave been used. The discretization has been done to map the material boundaries. There are a total of 183 elements to map the entire dam. The total number of nodes is 606. The nodes at the base of the dam are assumed to be fixed. The water pressure at full reservoir condition is taken as edge load on the u/s portion of the clay core. The discretization of the dam is shown in Fig.3(a). The element and node numbering are shown in Figs.3(b-d). Same finite element mesh is used for both single and multi lift analysis. The Mohr-Coulomb yield criteria is used to model the nonlinear behaviour of soil

The mesh is discretised in such a way that year wise construction layers are easily taken care in the analysis. The numbering of the elements is done horizontally to facilitate the computation for sequential construction

SOIL PROPERTIES

Having determined shear modulus at a confining pressure and shear strain level from tests on rockfill, it can be determined at any other confining pressure and shear strain level. Consideration of this effect, the stiffness of dam increases with depth. To take into this variation in the dam analysis, a power law variation of shear modulus has been used. The material shear modulus is assumed to vary with the confining pressure according to following power law

$$G = G_o(\sigma/\sigma_o)^m \qquad (1)$$

where G is the shear modulus at a confining pressure σ and G_o is the shear modulus at a specified confining pressure σ_o usually 1 kg/cm^2.

The material properties taken for the rockfill dam analysis are listed in Table 1 [Ref 2]

Table-1 Material properties [Ref.2]

sl no.	property	shell	rip-rap	core
1	shear modulus, G (t/m^2)	6000.0	6000.0	3000.0
2	modulus of elasticity (t/m^2) at 10(t/m^2) confining pressure	0.162e+05	0.162e+05	5400
3	Poisson's ratio	0.35	0.25	0.30
4.	moist density (t/m^3)	2.45	2.00	2.00
5	saturated density(t/m^3)	2.49	2.16	2.15
6	dry density (t/m^3)	2.36	1.80	1.85
7	cohesion, c (t/m^2)	7.00	0.50	5.00
8	effective angle of internal friction (degree)	42.0	42.0	28.0
9	power variation of G, m	0.5	0.5	0.3

The dynamic modulus of elasticity has been taken such that the fundamental time period of vibration of dam is 1.25 sec i.e. the static modulus of elasticity is multiplied by a factor $(1.6276/1.25)^2 = 1.6954123$, where 1.6276 sec is the time period of Section B-15 obtained with the static material properties

In static analysis, the submerged unit weight has been taken for the u/s shell element, except the top elements above the phreatic line of u/s shell for which dry density has been taken. Saturated unit weight has been taken for the core. Dry density has been taken for the d/s shell For dynamic analysis saturated unit weight has been taken for the u/s shell elements

ELASTO-PLASTIC ANALYSIS

In the analysis, the stress-strain relation which exhibit an elasto-plastic behaviour of soil is considered where the elasto-plastic behaviour follow the Mohr-Coulomb yield criterion. Three requirements have to be met in elasto-plastic analysis.

(i) An explicit relationship between stress and strain is formulated to describe material behaviour under elastic conditions, i.e. before the onset of plastic deformation. Before the onset of plastic yielding, the linear stress-strain relationship is expressed as

$$\sigma = D\varepsilon \tag{2}$$

where σ and ε are the stress and strain vectors, D is the elastic modulus matrix

(ii) A yield criterion indicating the stress level at which plastic flow commences is specified. In this Mohr-Coulomb yield criterion is considered.

The Mohr Coulomb yield criterion is a generalisation of the Coulomb friction law defined as

$$\tau = c - \sigma_n \tan\phi \tag{3}$$

where τ is the magnitude of the shearing stress, σ_n is the normal stress (tensile taken as positive), c is the cohesion and ϕ is the angle of internal friction. Graphically equation (3) represent a straight line tangent to the largest principal stress circle. This was first demonstrated by Mohr For $\sigma_1 \geq \sigma_2 \geq \sigma_3$ equation (3) can be rewritten as

$$F = \frac{1}{2}(\sigma_1 - \sigma_3) + \frac{1}{2}(\sigma_1 + \sigma_3)\sin\phi - c\cos\phi = 0 \tag{4}$$

The complete yield surface is obtained by considering all other stress combinations which cause yielding. In the principal stress space this gives a surface in the form of a hexagonal pyramid. The hexagonal section is irregular as shown in Fig.5. The conical rather than the cylindrical shape of the surface indicate that the hydrostatic stress does influence yielding. This dependence of hydrostatic stress is an established fact for materials like soil, rock and concrete

The equation (4) can be expressed in the form of the stress invarients I_1, J_2 and θ - first stress invariant, second deviatoric stress invariant and Lode angle respectively as

$$F = \frac{1}{3} I_1 \sin\phi + J_2^{1/2}(\cos\theta - \sin\theta\sin\phi / \sqrt{3}) - c\cos\phi = 0 \qquad (5)$$

(iii) The stress-strain relationship is specified for post yield behaviour. After initial yielding the material behaviour will be partly elastic and partly plastic. During any increment of stress, the changes of strain are assumed to be divisible into elastic and plastic components, so that

$$d\varepsilon = (d\varepsilon)_e + (d\varepsilon)_p \qquad (6)$$

The plastic strain component and the stress increment is defined by flow rule

$$(d\varepsilon)_p = d\lambda \frac{\partial F}{\partial \sigma} \qquad (7)$$

where $d\lambda$ is a proportionality constant termed as plastic multiplier.

The matrix formulation of the plastic stress-strain relationship in incremental form is expressed as

$$d\sigma = D_{ep} d\varepsilon \qquad (8)$$

where D_{ep} is the elasto-plastic constitutive matrix, the detail is given in Ref.4.

For the solution of static nonlinear elasto-plastic problems, the following incremental equation is satisfied at discrete points

$$\Delta\psi - K_T u - (\Delta f + \int_\Omega N^T \Delta b \, d\Omega) \neq 0 \qquad (9)$$

where $K_T = \int_\Omega B^T D_{ep} B \, d\Omega$ is the tangential stiffness matrix, u is the displacement, ψ is the residual force vector B is the strain displacement matrix; N is the shape function matrix, b is the distributed loads/unit volume and f is the external applied forces

For an elasto-plastic situation the material stiffness beyond elastic limit is continuously varying, and instantaneously the incremental stress/strain relationship is given by (8). The residual forces ψ can be interpreted as a measure of the departure from equilibrium. Equation (9) is solved using Newton-Raphson iterative scheme.

For dynamic analysis equilibrium is satisfied at discrete time interval Δt at time station n+1, following nonlinear equation is solved

$$M\ddot{u}_{n+1} + p_{n+1}(u_{n+1}, \dot{u}_{n+1}) = f_{n+1} \qquad (10)$$

where M is the mass matrix, p is the internal nodal forces depending upon the nodal displacement u and nodal velocity $\dot{u}$

The equation (10) is written in incremental-iterative form using Newmark's integration scheme.

$$K^{*}\Delta u^{i} = \psi^{i} \qquad (11)$$

where, $K^{*} = M/(\beta\Delta t^{2}) + \gamma C_{T}/(\beta\Delta t) + K_{T}$

and $\psi^{i} = f_{n+1} - M\ddot{u}^{i}_{n+1} - p^{i}(u^{i}_{n+1}, \dot{u}^{i}_{n+1})$

β and γ are the Newmark's integration constants, Δt is the time step length of integration and C_T is the damping matrix

The response evaluation provides time histories of stress, displacement and acceleration at desired locations/element during the earthquake.

ANALYSIS OF THE DAM

Static and earthquake response analysis is carried out to study the stability of dam Finite element method is an important tool to determine the stresses and deformations of a dam during the construction phase and normal operating conditions.

Static analysis: Analysis of the high rockfill dam is carried out for static loads due to self weight, water pressure and uplift. Static deformation s of dam are of interest because excessive deformations can lead to loss of free board and danger of over topping. Excessive spreading may lead to longitudinal cracking and adversely affect stability. Differential settlement along the axis of the dam may lead to transverse cracking which could allow passage of water. Differential settlement between the core and shell can lead to stress reduction in the core and may result in hydraulic fracture.

Determination of initial static stresses: In static analysis it is convenient to use incremental procedure. The main reasons are

- They permit simulation of actual sequence of events involved in construction and loading of the dam. The geometry of the finite element mesh can be changed during each increment of the analysis to simulate addition of fill to the embankment, and water loads can be added in stages, simulating the rise of the water level in the reservoir.

- They permit simulation of nonlinear and stress-dependent behaviour of the rock fill. The values of modulus and Poisson's ratio assigned to each element can be adjusted during each increment of the analysis in accordance with the values of stress calculated in the analysis.

Analysis is made to determine the internal deformation of the core and the shell, obtaining stress distribution and load transfer within the dam section, location of zones of potential cracking resulting from tensile stresses and investigating the likelihood of hydraulic fracturing.

Sequence of construction: Table 2 indicate the sequence of construction as detailed out by the project authorities.

Table -2 Sequence of construction of Tehri dam

Year of construction	Dam level (m)	Water level in reservoir (m)
1	661.0 (coffer dam) 638.0 (main dam)	656.0
2	700.0	656.0
3	760.0	706.0
4	820.0	742.0
5	839.5	715.0
6	839.5	830.0

Figures 6(a-h) show the eight stages of construction and reservoir fillings. The dam is proposed to be constructed in five years The figures also show the loading at various stages In the case of water impounded in the reservoir the weight of the rockfill under water is taken as submerged while the water pressure is assumed to act on the sloping face of the core as an external load.

Frequency analysis: The frequency analysis has also been carried out to study the free vibration characteristics of the dam based on the final stress distribution obtained from nonlinear static analysis

Earthquake response analysis It is evaluated for the postulated seismic environment It involves the determination of the initial stress in the embankment before the earthquake and estimation of acceleration time history of the postulated earthquake at the base rock Evaluation of the rockfill dam response to the base rock excitation is then carried out which requires appropriate soil model and soil properties Response of the dam include the evaluation of stresses, deformations and stability of cross section of the rockfill dam

RESULTS AND DISCUSSIONS

Static stresses

Stresses due to both single and multiple lift nonlinear static analysis by finite element method has been carried out.

Single Lift Linear Analysis: Single lift linear static analysis is carried out to assess th stress distribution in the dam body. Figure 7 shows the stress contours of the normal vertical stresses, shear stresses, major principal stresses and the minor principal stresses. The normal vertical stresses are concentrated near the d/s base of the core

The contours of the shear stresses are plotted in Fig.7(b). The maximum value of the shear stresses is 50 t/m^2 at the d/s core base.

Figure 7(c) shows the plot of the maximum principal stress contours. The peak major principal stress of -120 t/m^2 (compressive) occurs at the u/s filter junction with the core near the base of the dam. A zone of tension is observed at the u/s face with maximum of 50 t/m^2

The minor principal stresses are plotted in Fig 7(d) The peak value of the stress (260 t/m^2) occurs at the d/s base of the dam. Again the stresses are predominantly compressive in nature.

Thus from the contour plots, it can be seen that the stress concentration zones lie at the irregular base of the dam. Though the principal stress is mostly compressive there is a small tension zone on the u/s side of the dam. The stress distribution of the normal vertical stress and the minor principal stress are almost identical.

Figures 8 and 9 show vertical and horizontal deformation of the dam body The maximum vertical and horizontal displacements of 0.75m and 0.5m occur at the crest of the dam

Multi lift Nonlinear Analysis: For multi lift nonlinear analysis the construction schedule of raising of the dam and the schedule of reservoir filling was taken into account In the first lift, only a portion of d/s is laid and static analysis for gravity load is carried out. Similarly, other layers are also analysed. The initial stresses of the previous layer were taken into account.

In the case of sequential construction however each layer is considered separately The analysis is first carried out for the first layer using trail values of E and ν for each element. The evaluated stresses are used to calculate the confining pressure which is used to calculate the corrected value of E The procedure is iterative and iterations are continued till convergence is met.

Eight stages are considered for the nonlinear multi lift analysis. The normal vertical stresses, shear stresses, major principal stresses, minor principal stresses are determined for each layers and the stress contours are plotted in Figs. 10 to 17

The contours of plastic strains are also plotted at each stage of construction and are shown in Figs.18 to 24. It is seen that the plastic strains are confined mostly near the surface of u/s and d/s slopes.

Figures 25 and 26 show the vertical and horizontal deformations obtained from multi lift analysis. The maximum vertical and horizontal displacements are found to be 0.6m and 0.4m near the centre of d/s shell while Figs. 8 and 9 show the horizontal and vertical deformations of the dam for one lift linear elastic analysis and the maximum vertical displacement and horizontal displacement are found to be 0.75 m and 0.5m near the crest

Free Vibration Characteristics Of The Dam

For computation of eigen values and the mode shapes the inverse iteration technique is used for the solution. For the eigen value analysis, the stiffness of the dam section is evaluated considering the variation of the Young's modulus with the depth of the dam. The variation of the Young's modulus is computed from the power variation. Since the values of the Young's modulus are known at a confining pressure of 10 t/m^2, Young's modulus of elasticity can be computed at any other confining pressure. The power (m) is taken as 0.5 for the shell material whereas for clay it is taken as 0.3. Nonlinear variation of the Young's modulus E is computed from the initial stresses obtained by nonlinear multi lift static analysis at the end of construction. The time periods of the dam for the first eight modes are shown in Table-3.

Table-3 Frequencies and Time Periods of the dam

mode no	frequency in (Hz)	time period T (sec)
1	0.8000	1.2500
2	1.1920	0.8389
3.	1.2985	0.7701
4	1.4850	0.6734
5	1.5783	0.6336
6.	1.7504	0.5713
7	1.7995	0.5557
8.	1.8822	0.5313

Figures 27 and 28 show the first eight mode shape of vibrations of the dam As can be seen from the figure that the first mode of vibration of the dam has a time period of 1.25 sec. which is predominantly a lateral translation mode.

Earthquake response

Figure 29 shows the time history of horizontal and vertical accelerations at the crest obtained from non-linear analysis and their peak values are 9.59 m/s^2 (nearly 1.0g) and 4.26 m/s^2 respectively. Figure 30 show the time history of horizontal and vertical displacements at the crest and their peak values are 38.7 cm and 14.78 cm respectively. Figure 31 show the time history of principal stresses at the base of the core.

As a comparison with the linear analysis the Figure 32 shows the time history of horizontal and vertical accelerations at the crest obtained from linear analysis and their peak values are 10.69 m/s^2 (more than 1.0g) and 4.063 m/s^2 respectively. Figure 33 shows the time history of horizontal and vertical displacements at the crest and their peak value are 30.4 cm and 7.06 cm respectively. Figure 34 show the time history of principal stresses at the base of the core.

Figure 35 show the plastic strain developed in the dam body at the end of the earthquake. It is seen that the plastic strain are confined mainly to u/s and d/s surfaces of the dam. The maximum plastic strain is found to be 0.08.

SUMMARY

The static and the free vibration response of the rockfill dam is carried out taking into account the effect of material property variation with confining pressure, non linearity, the schedule of raising the dam and the schedule of reservoir filling.

Static Response

Single lift linear analysis: The single lift linear analysis shows a tension region near the u/s side and the crest of the dam. The peak value of major principal stress is 120.0 t/m^2 (compressive) while the peak minor principal stress is found to be 260.0 t/m^2 occurs at the d/s base of the dam.

Multi lift Nonlinear Analysis: The multi lift nonlinear analysis shows no tension region in the shell which is more realistic since the loading applied is primarily gravity loading. The peak stresses and stress distribution obtained are comparable to those obtained by single lift linear analysis. The nonlinear stress distribution is more realistic since the single lift analysis assumes a "switch on" kind of a gravity loading, which is not the case.

The vertical and horizontal deformations obtained from multi lift analysis are found to be 0.6m and 0.4m near the centre of d/s shell while the one lift linear elastic analysis show that the maximum vertical displacement and horizontal displacement are found to be 0 75 m and 0.5m near the crest.

Thus it can be concluded that the nonlinear multi lift analysis gives a more realistic view of the stress and deformation distribution in the dam body.

Free Vibration Characteristics

The free vibration analysis is carried out taking into account the variation of Young's modulus with depth. The variation of the Young's modulus is computed from the power distribution. Nonlinear variation of the Young's modulus was computed from the initial stresses obtained by nonlinear multi lift analysis

The dynamic material properties are modified so as to achieve fundamental time period of vibration equal to 1.25 sec. The fundamental vibration mode shape is a lateral translation mode and the second mode shape is primarily a vertical translation mode The translations are much more pronounced near the crest of the dam.

Earthquake Response

The nonlinear dynamic analysis has been carried out for the postulated ground motion at Tehri dam site. The peak values of horizontal and vertical accelerations at the dam crest are found to be 9.59 m/s^2 (nearly 1.0g) and 4.26 m/s^2 respectively. The peak values of horizontal and vertical displacements at the dam crest are found to be 38 7 cm and 14.78 cm respectively.

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CONCLUSIONS

The nonlinear multi lift static and earthquake response analysis has given the insight of the dam response with respect to stresses, plastic deformations, peak accelerations, and peak displacements. The analysis of the dam reveals that the proposed Tehri dam undergo plastic deformations mostly near the d/s and u/s slopes of the dam which may not lead to any possible failure. The plastic deformations in rockfill material means adjustment of rockfill material by undergoing plastic deformations. Under the MCE condition, the dam is permitted to undergo limited damage without causing failure. The order of peak accelerations and deformations are within the acceptable limits under the postulated MCE at the site and thus the dam is found to be adequate.

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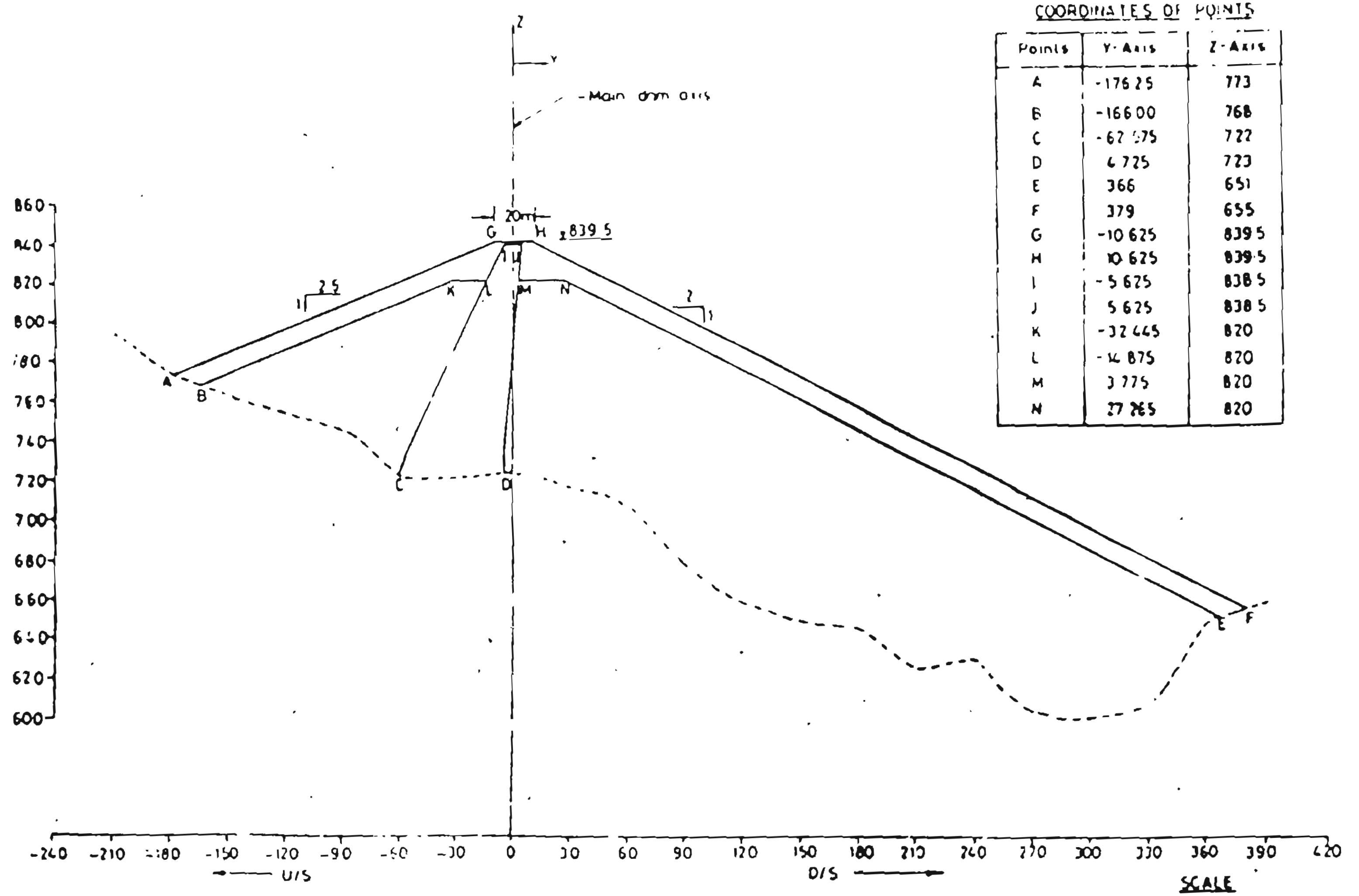
4. Owen, D.R.J. and E. Hinton(1980), Finite Elements in Plasticity. Theory and Practice, Pineridge Press Limited, Swansea, U.K.



COORDINATES OF POINTS

Points	Y-Axis	Z-Axis
A	-176.25	773
B	-166.00	768
C	-67.375	722
D	4.725	723
E	366	651
F	379	655
G	-10.625	839.5
H	10.625	839.5
I	-5.625	838.5
J	5.625	838.5
K	-32.445	820
L	-14.875	820
M	3.775	820
N	27.265	820

Fig.1 Cross section of the Tehri dam at Section B-15

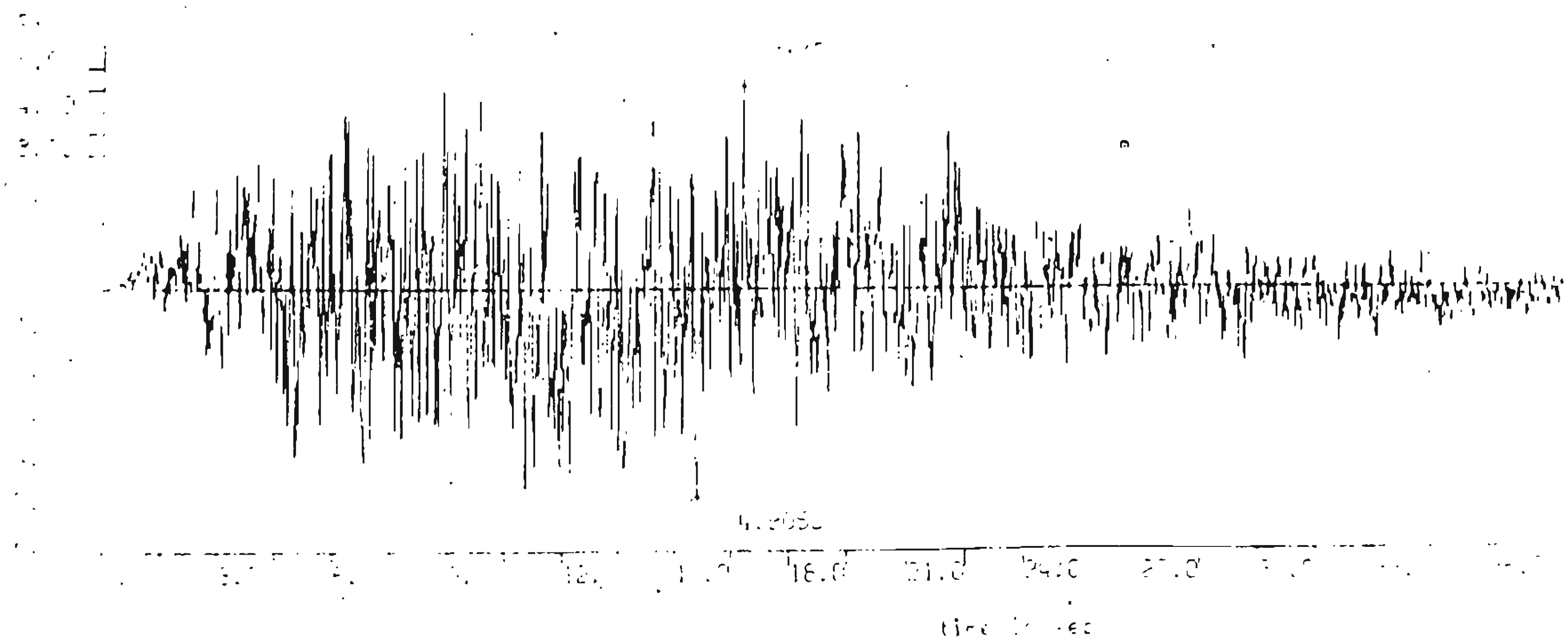


Fig.2 Postulated earthquake at Tehri dam site (PGA=0.5g or 4.905 m/s^2)

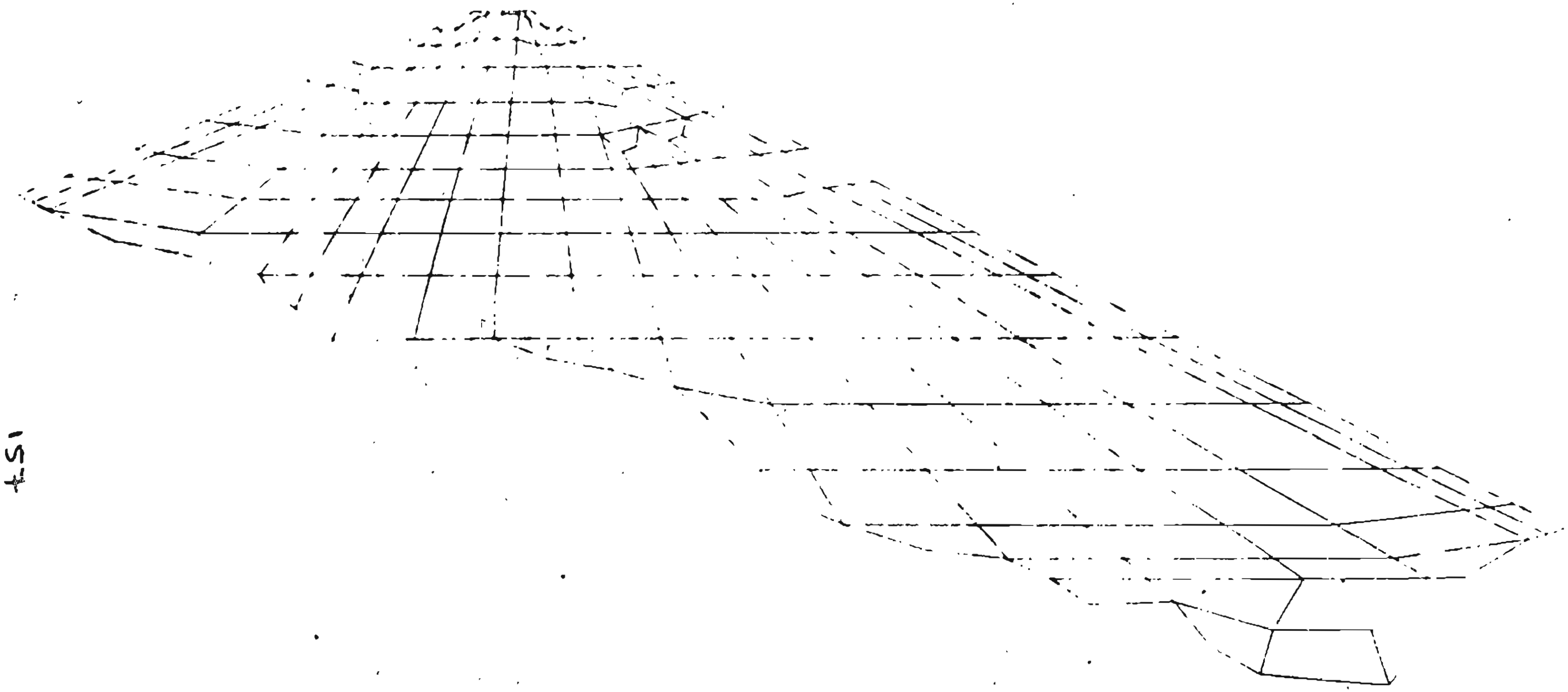


Fig.3(a) Finite element discretisation of the dam section

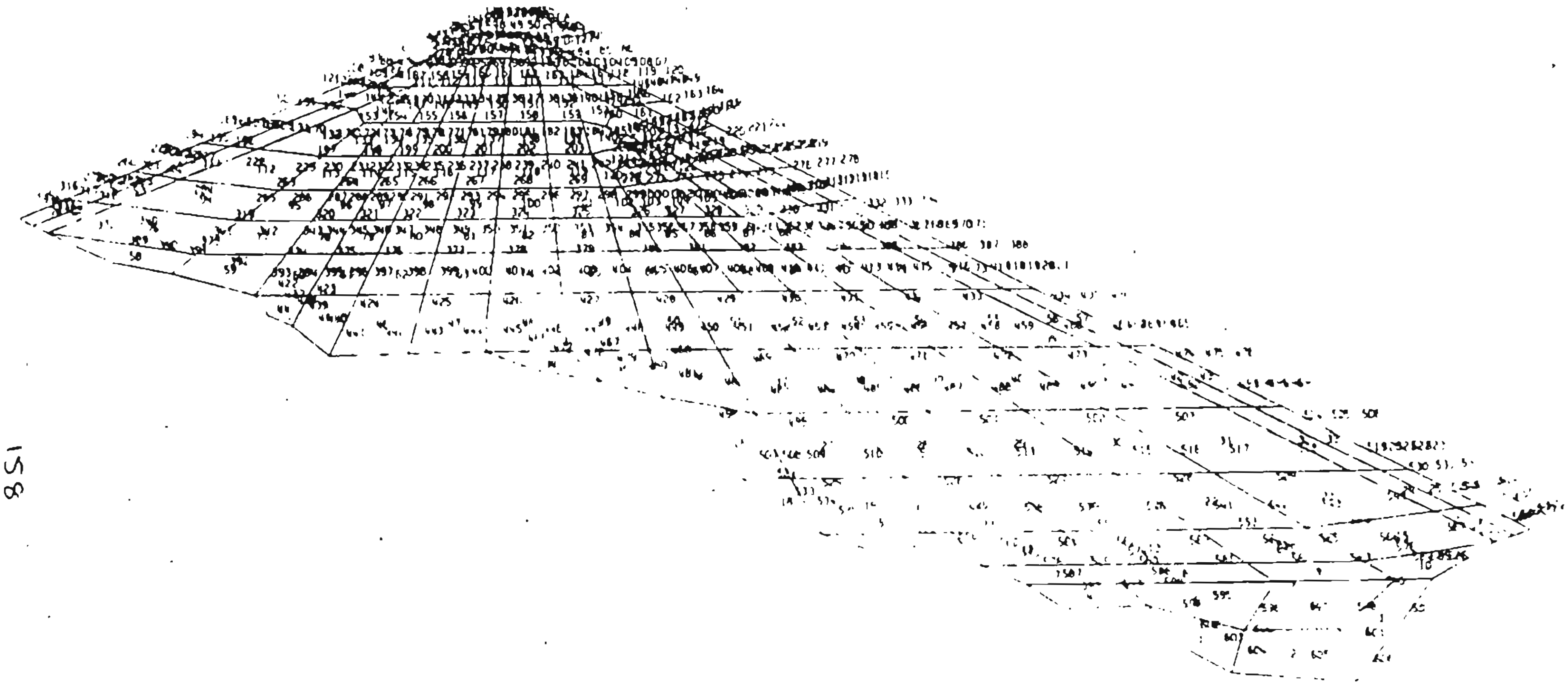


Fig.3(b) Finite element mesh showing element and node numbers

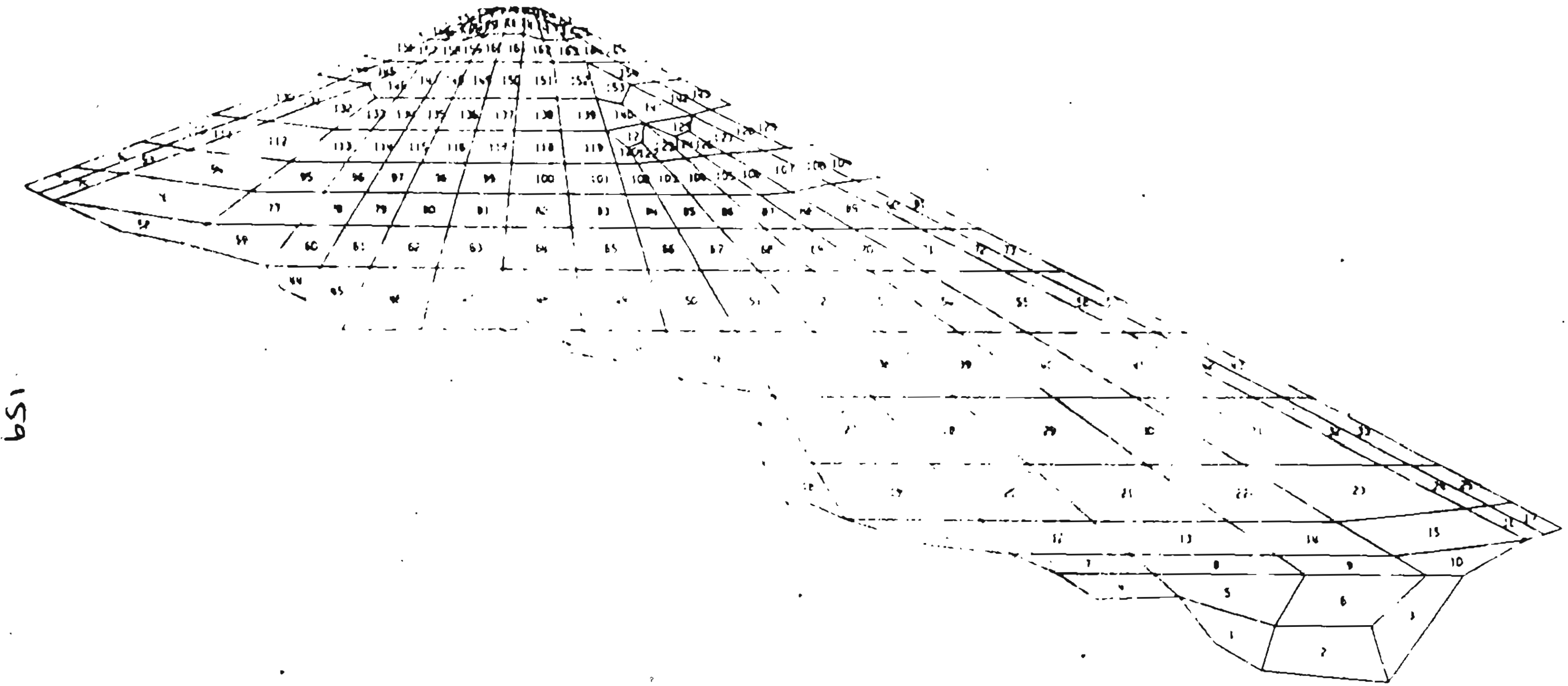


Fig.3(c) Finite element mesh showing element numbers only

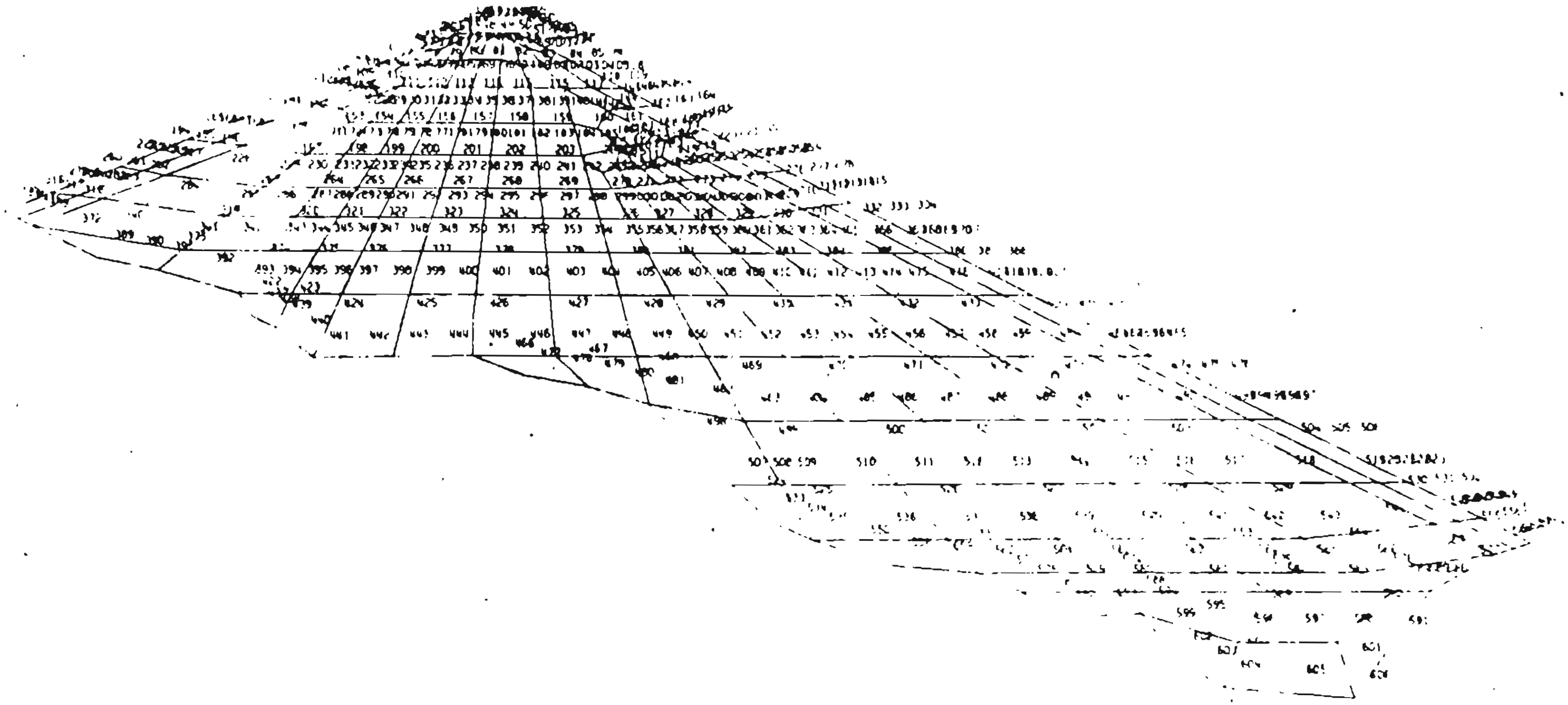


Fig.3(d) Finite element mesh showing node numbers only

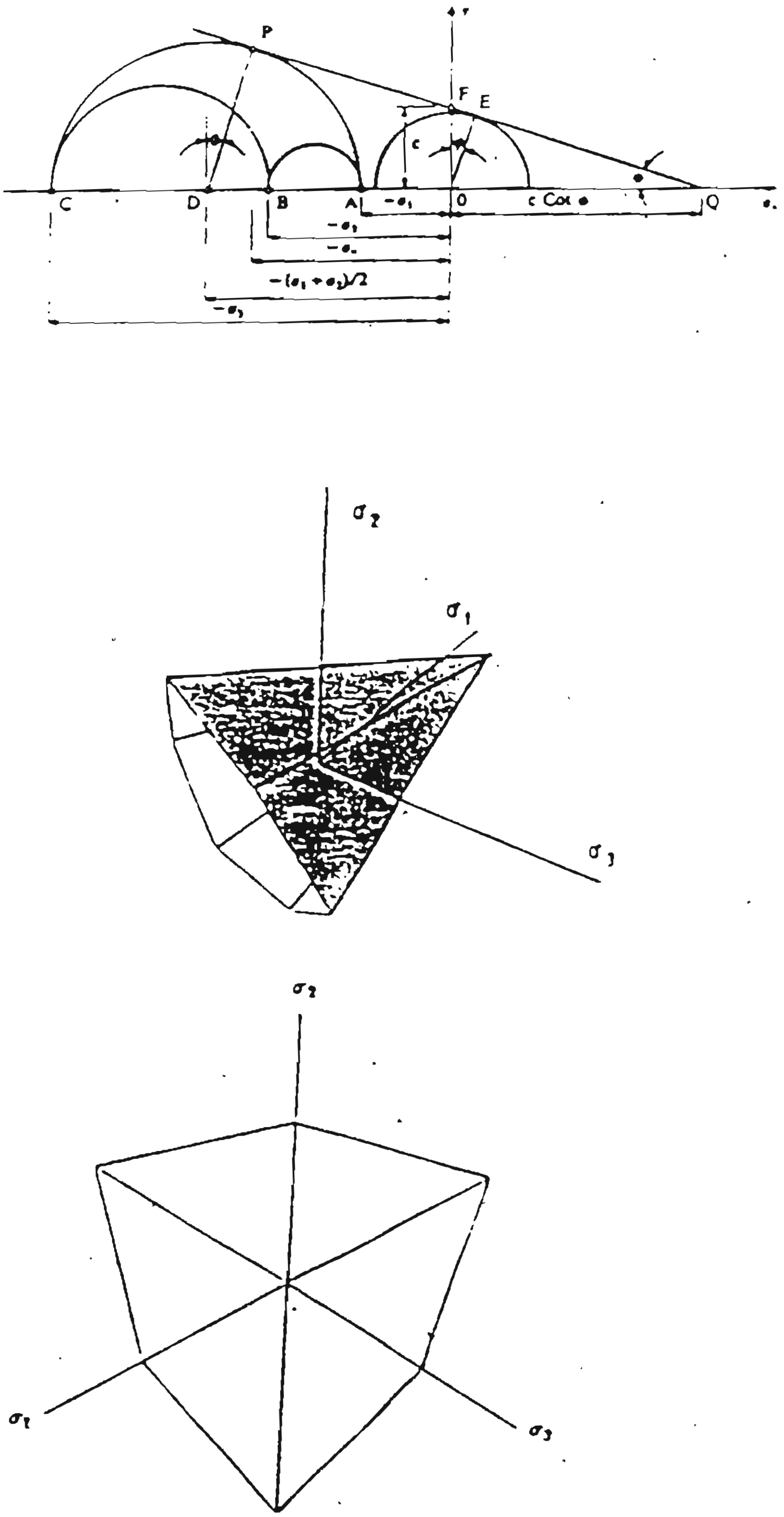


Fig.5 Mohr Coulomb Yield Surface (a) Mohr Circle Representation, (b) Principal Stress Space, and (c) π plane representation

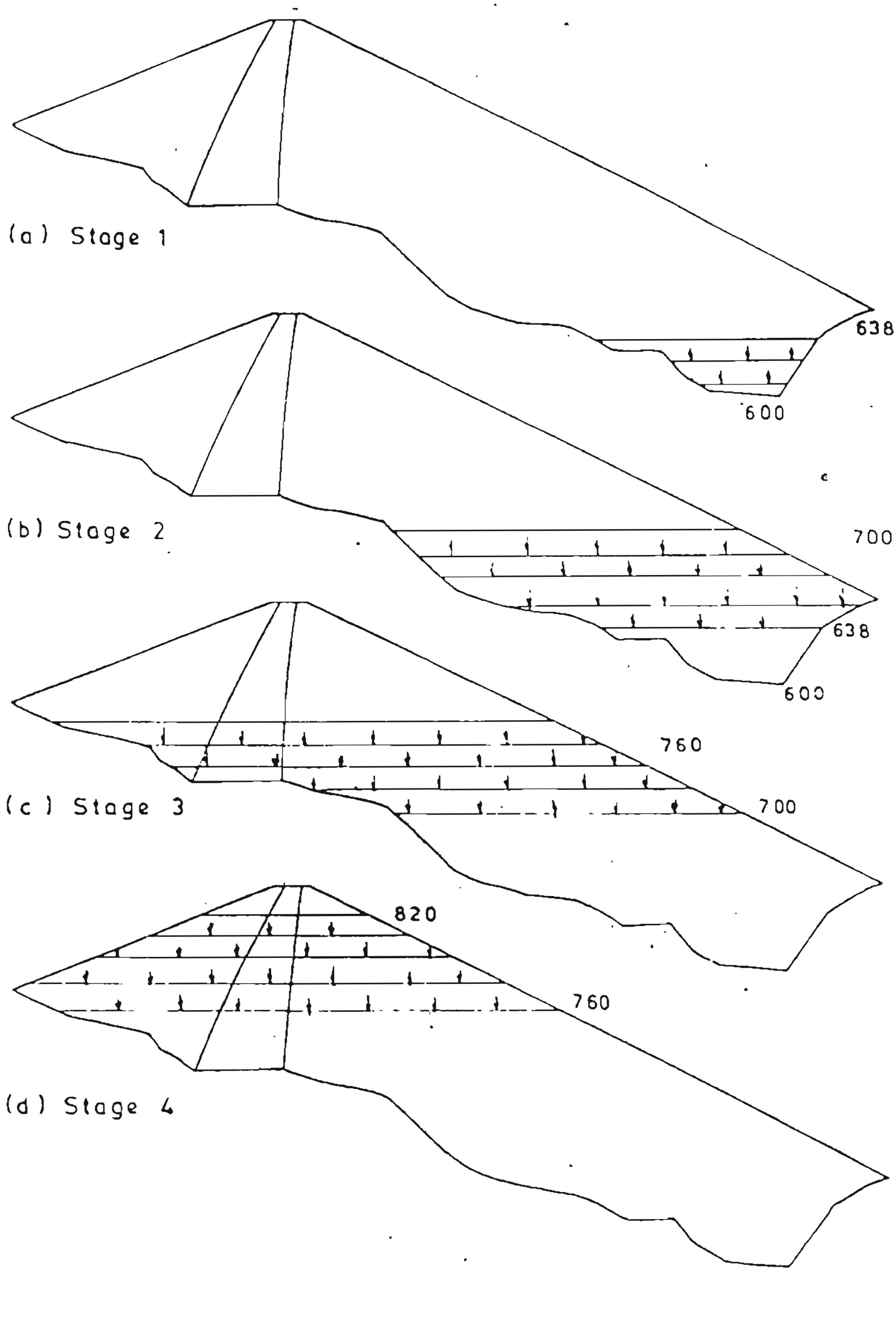


Fig 6(a) Sequence of construction and reservoir loads (cont...)

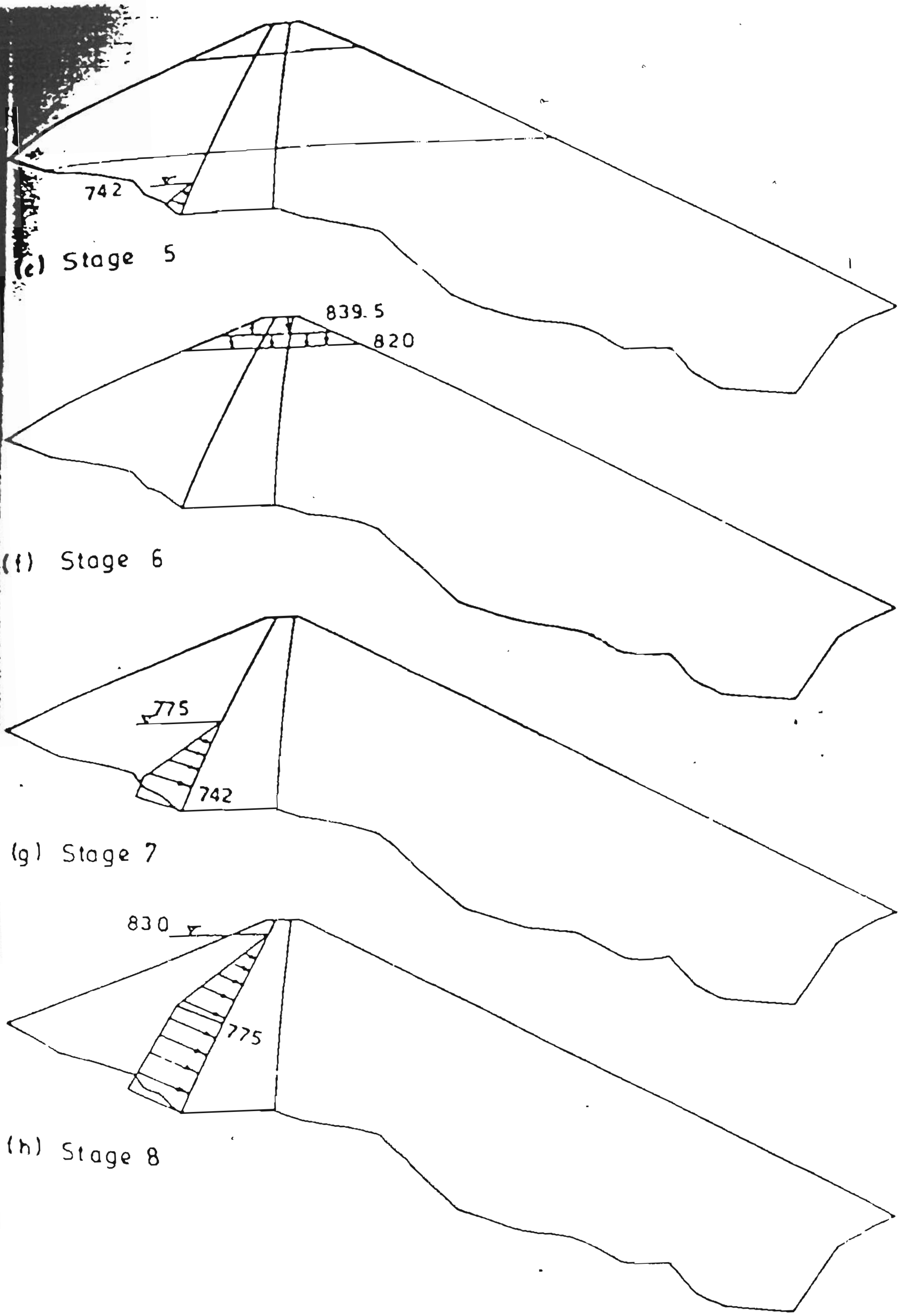


Fig 6(b) Sequence of construction and reservoir loads

Fig.7 Linear static stress - single lift

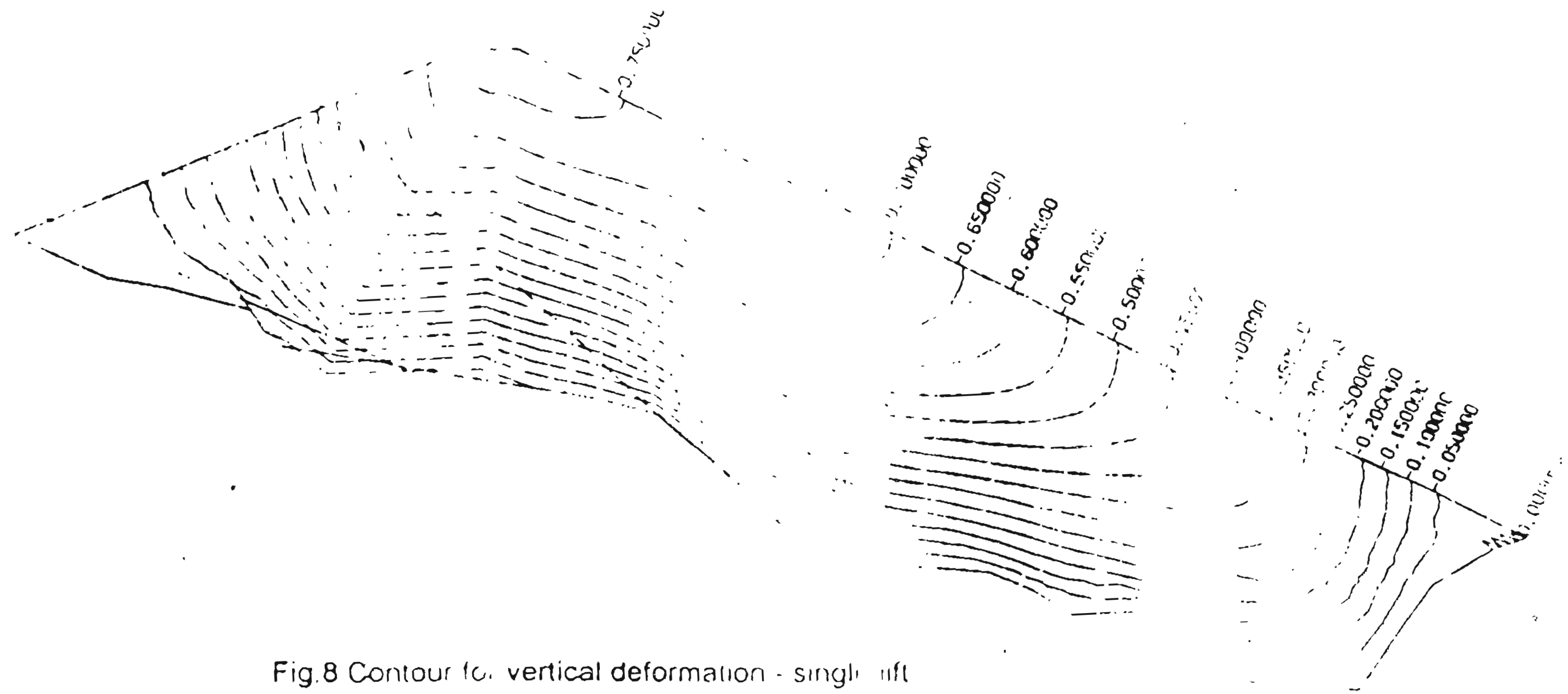


Fig.8 Contour for vertical deformation - single lift

Fig.9 Contour for horizontal deformation - single lift

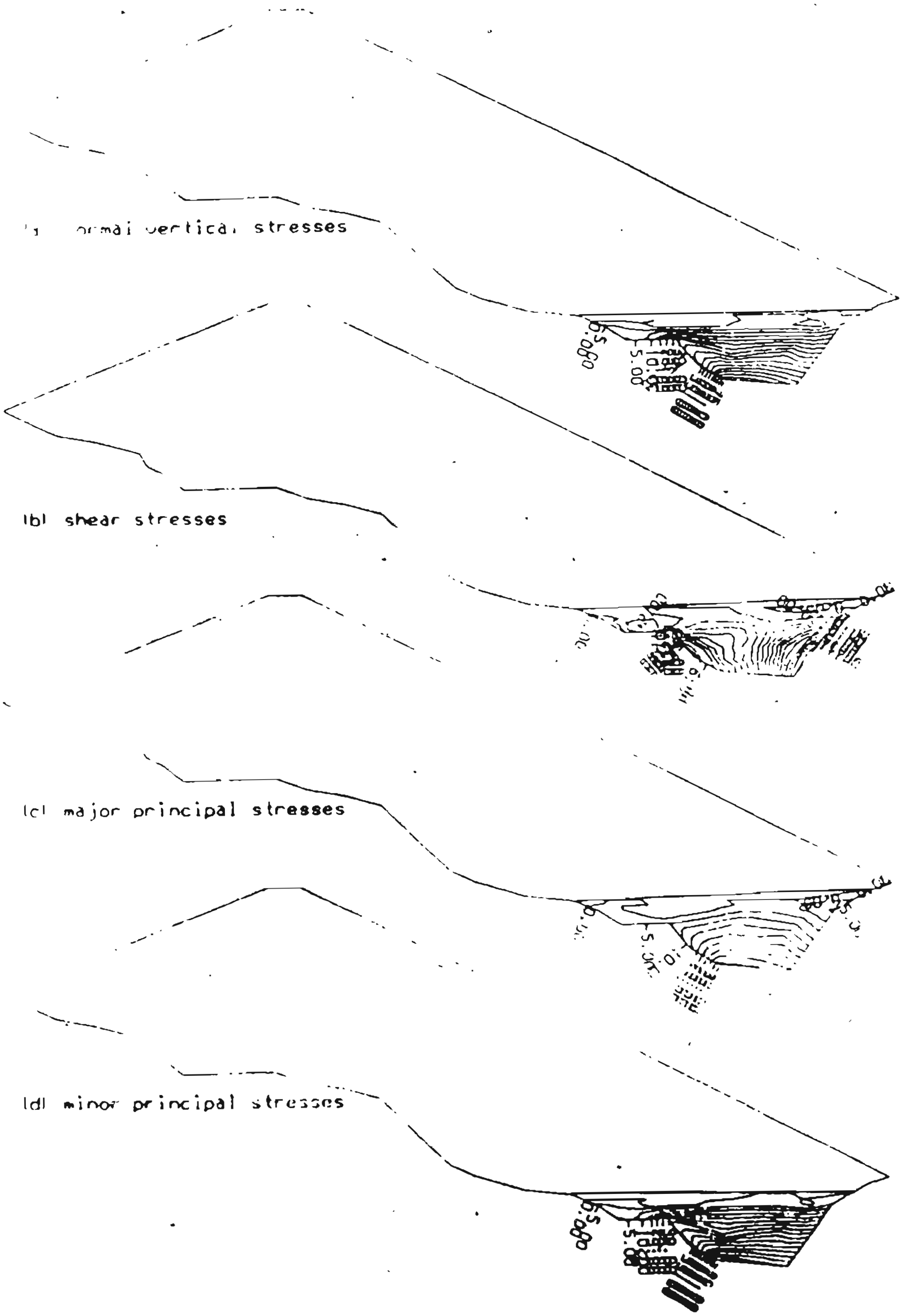


Fig.10 Nonlinear static stress - first lift analysis (stage 1)

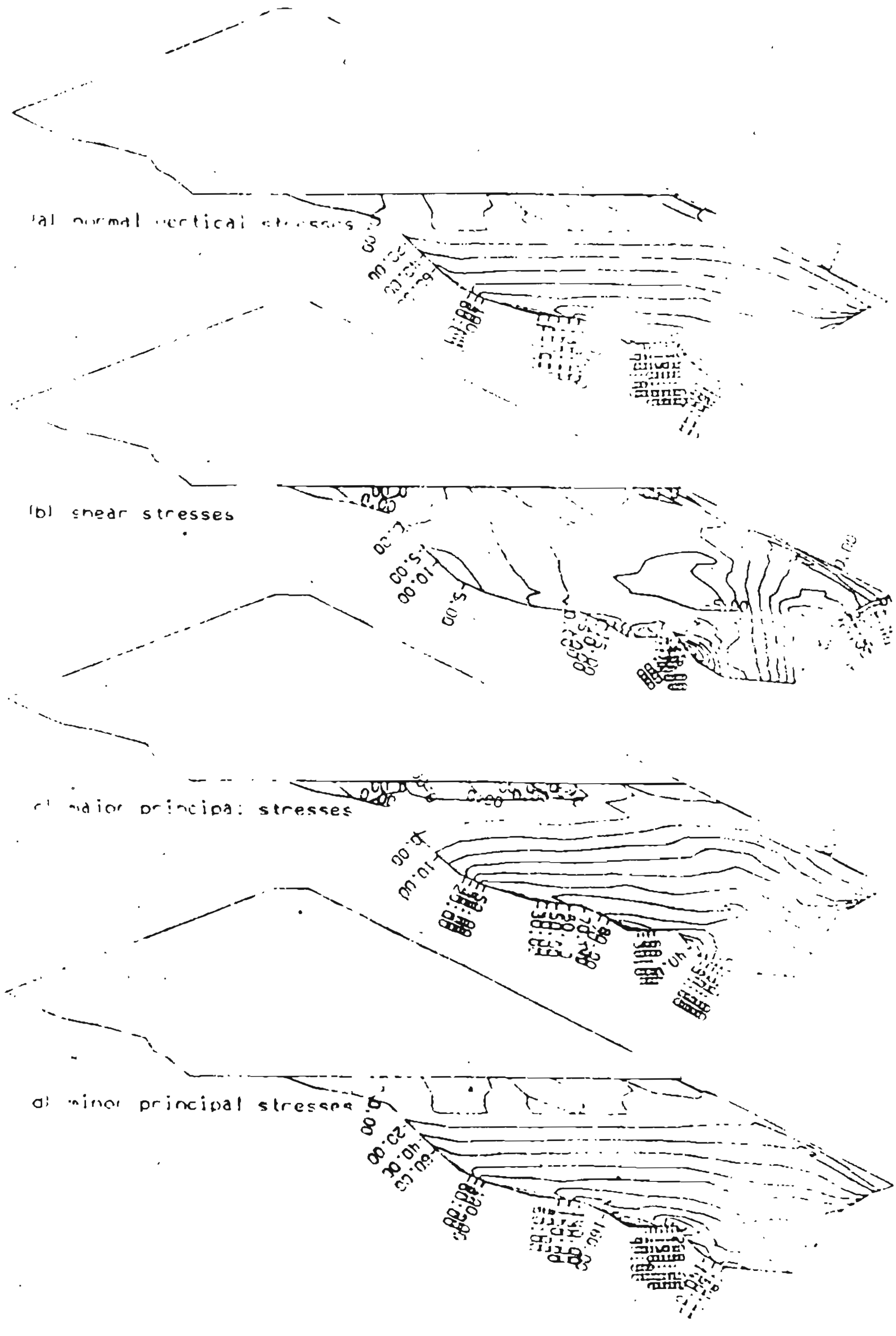


Fig.11 Nonlinear static stress - second lift analysis (stage 2)

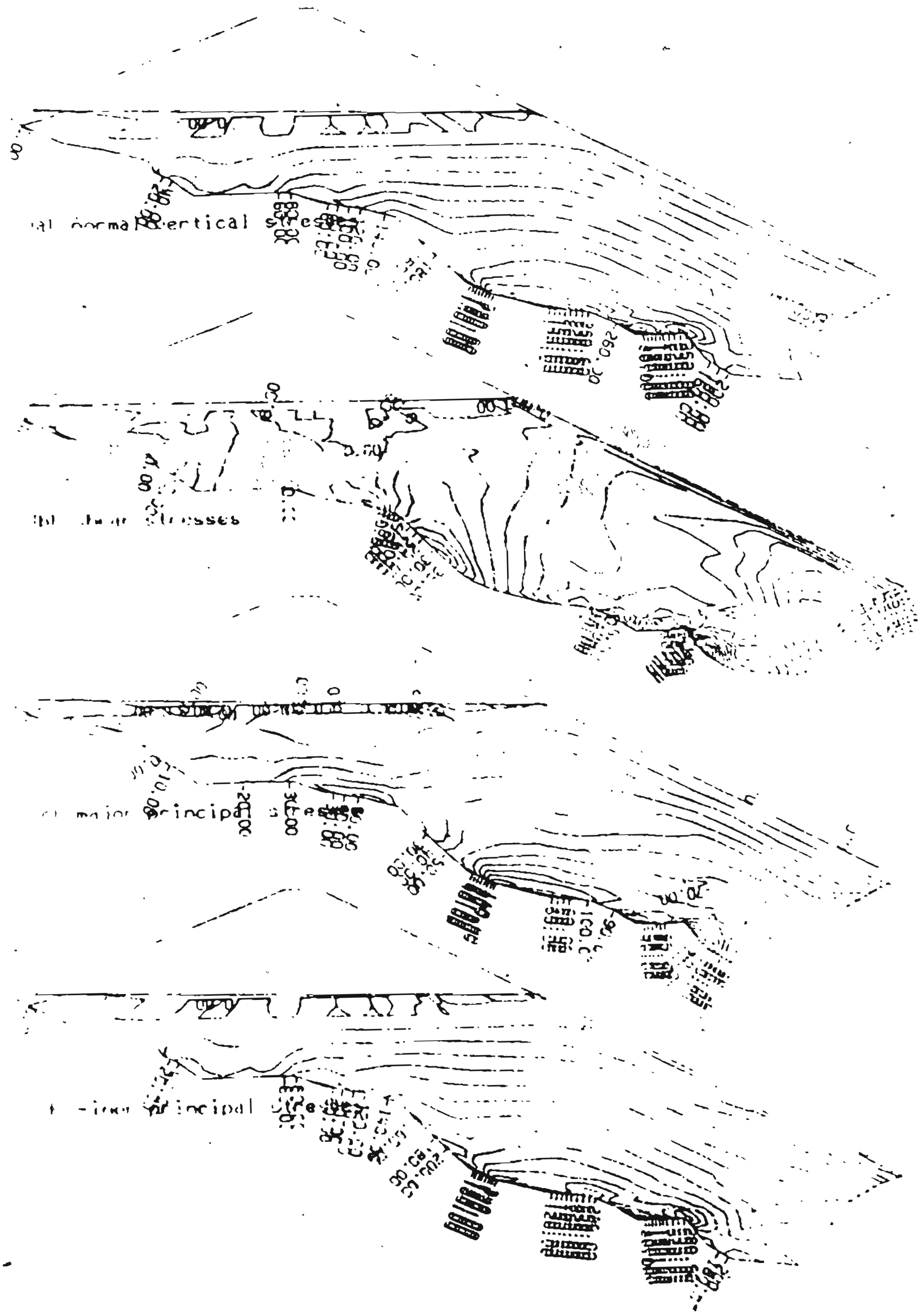


Fig.12 Nonlinear static stress - third lift analysis (stage 3)

Fig.13 Nonlinear static stress - fourth lift analysis (stage 4)

Fig.14 Nonlinear static stress -fourth lift reservoir filling upto EL. 742 (stage 5)

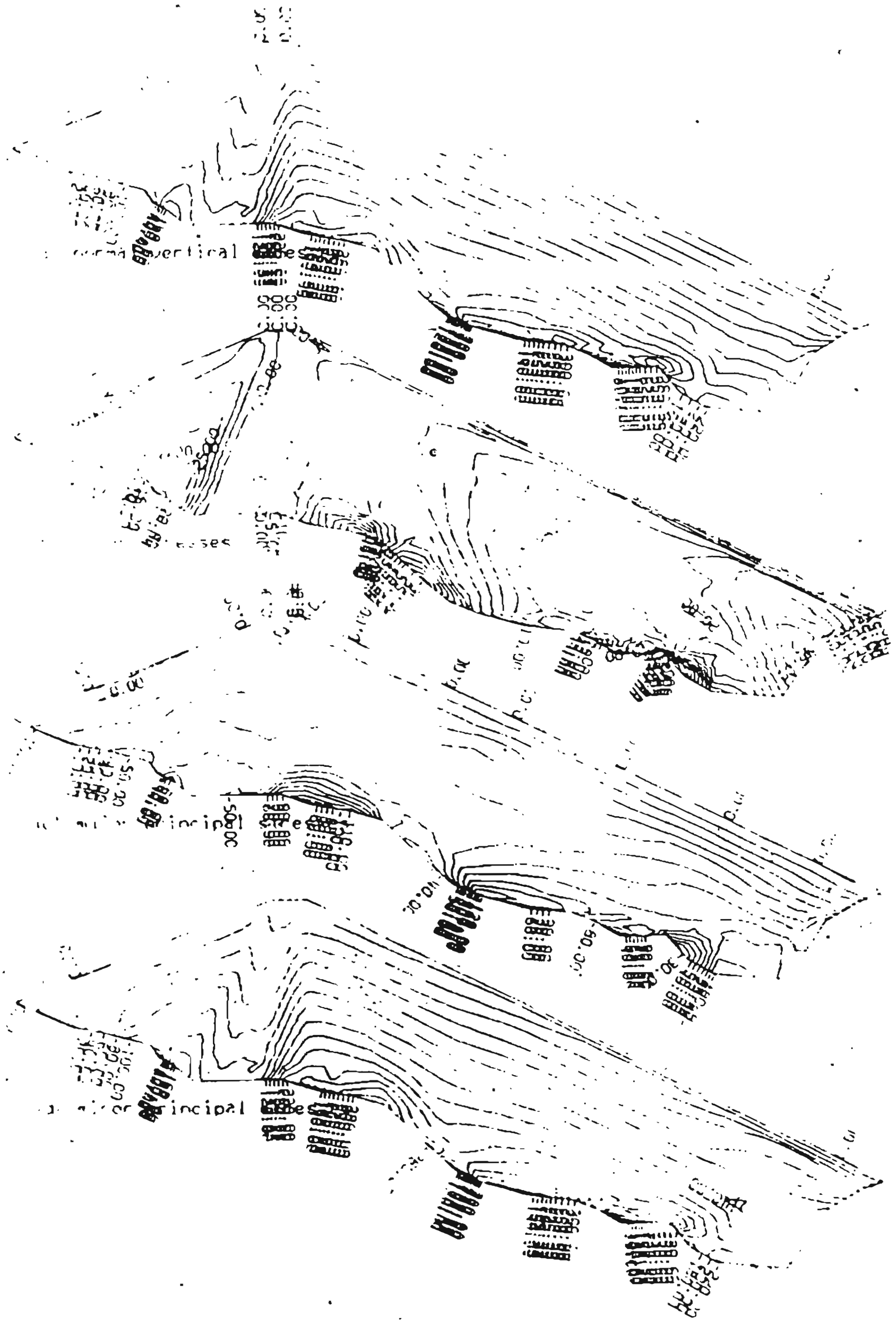


Fig.15 Nonlinear static stress - fifth lift analysis (stage 6)

Fig.16 Nonlinear static stress - fifth lift reservoir filling upto El. 775 (stage 7)

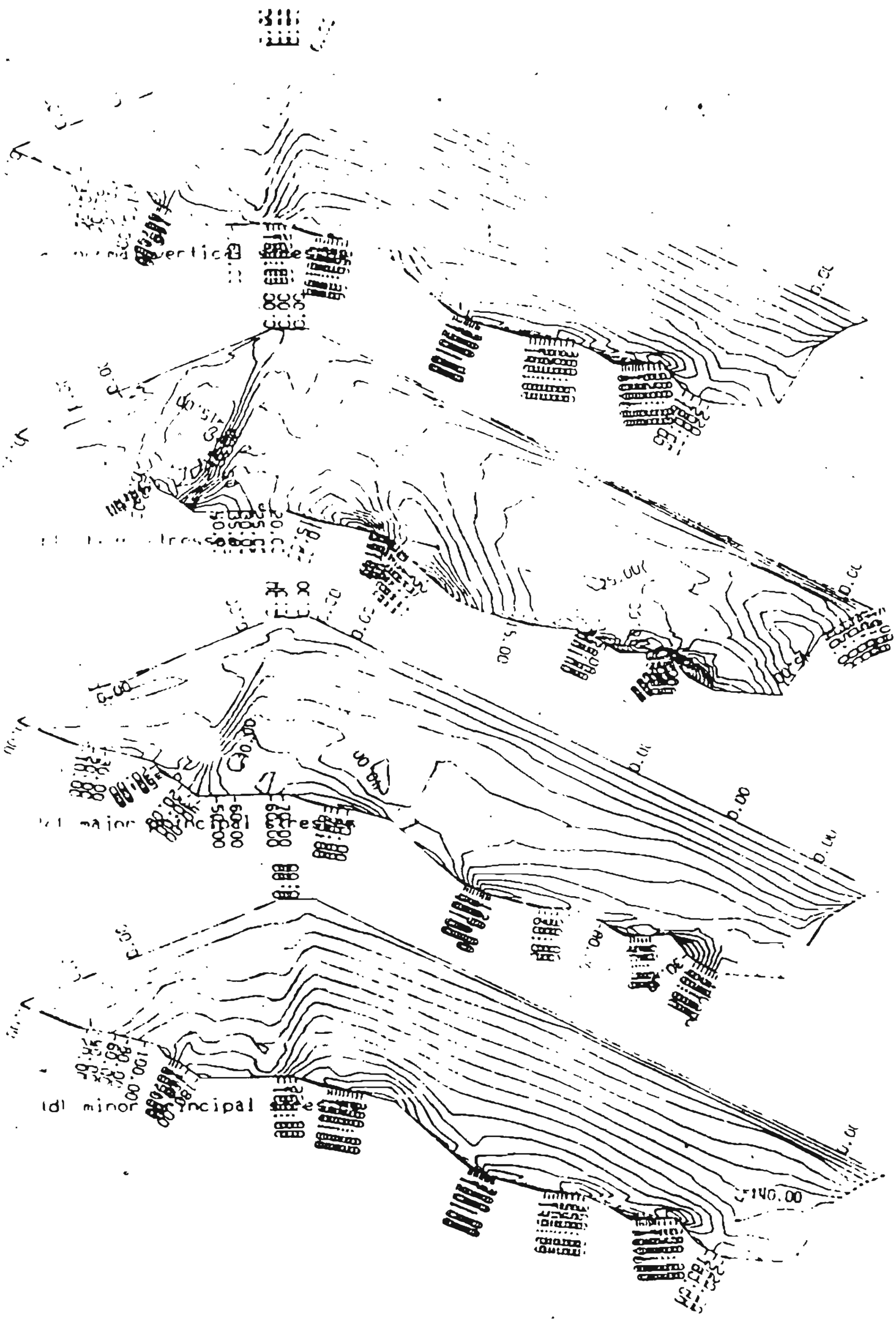


Fig.17 Nonlinear static stress - fifth lift reservoir filling upto El. 830 (stage 7)

Fig.18 Contours for plastic strain - stage 2

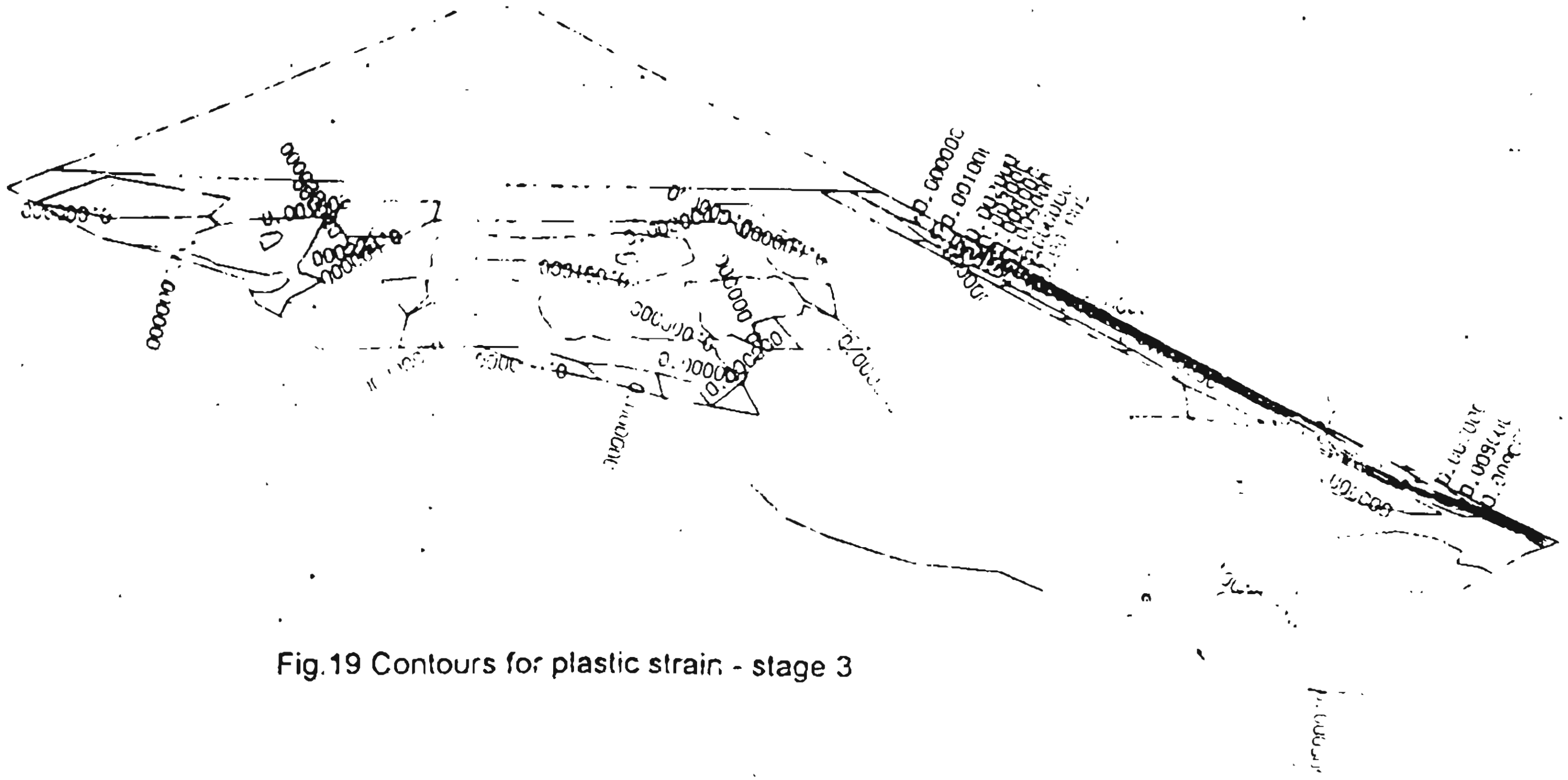


Fig.19 Contours for plastic strain - stage 3

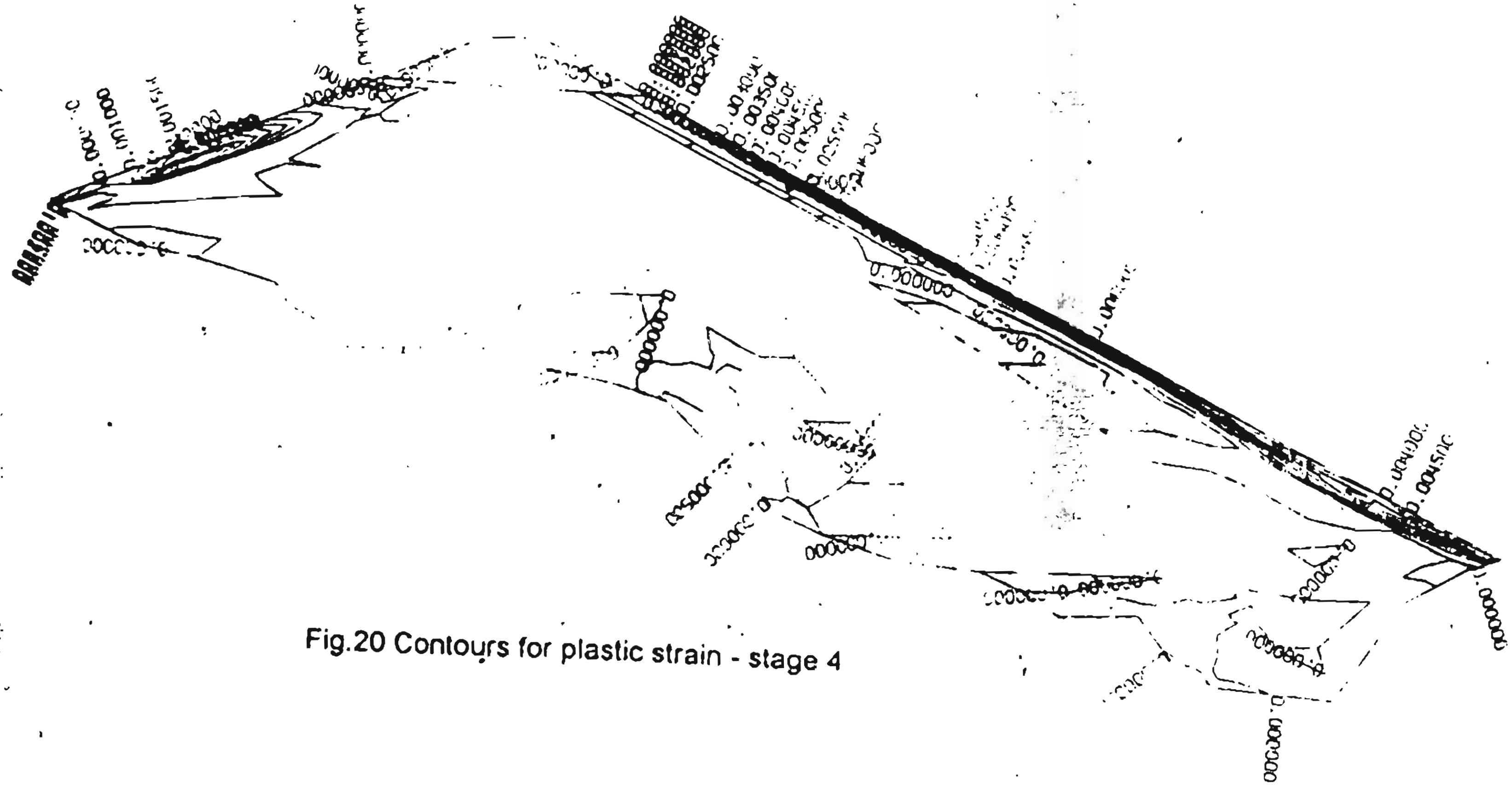


Fig.20 Contours for plastic strain - stage 4

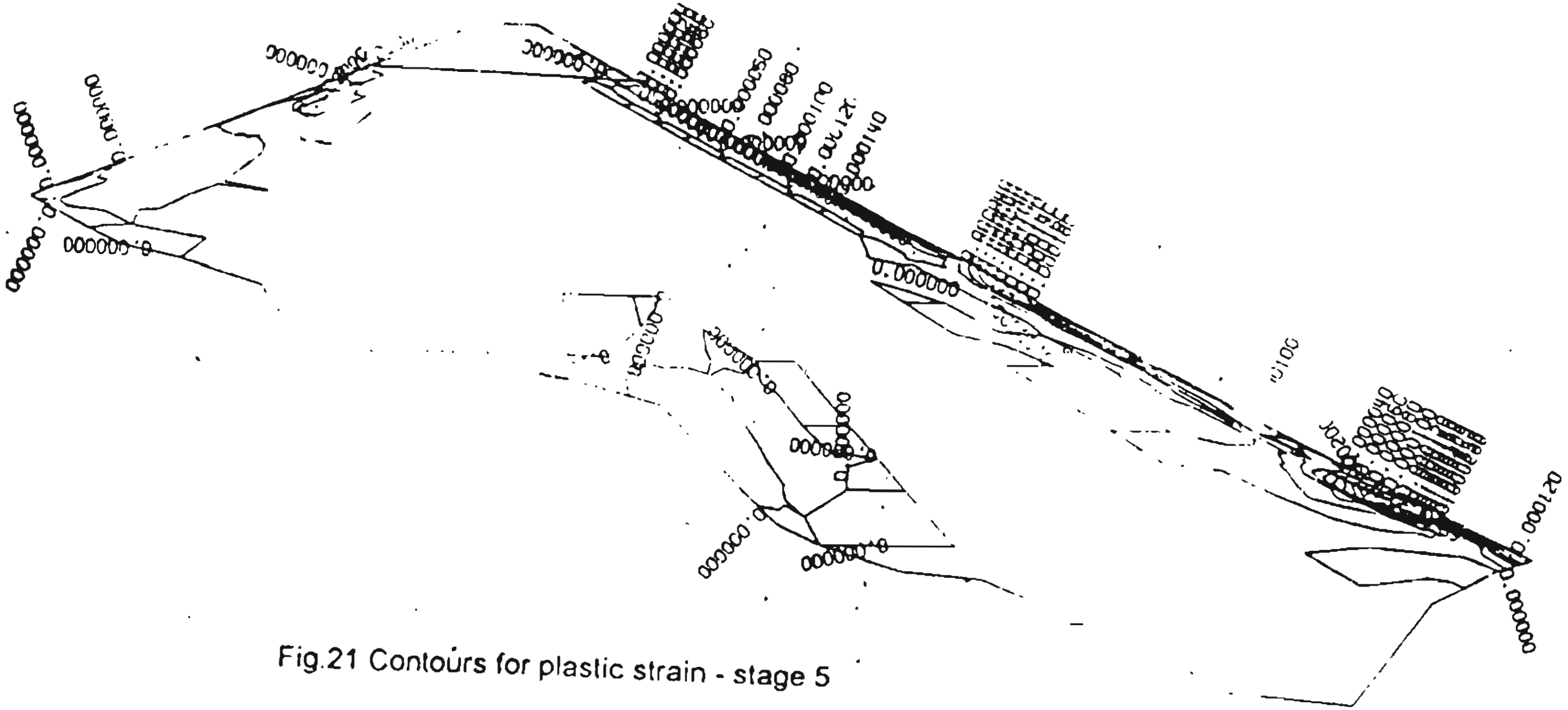


Fig.21 Contours for plastic strain - stage 5

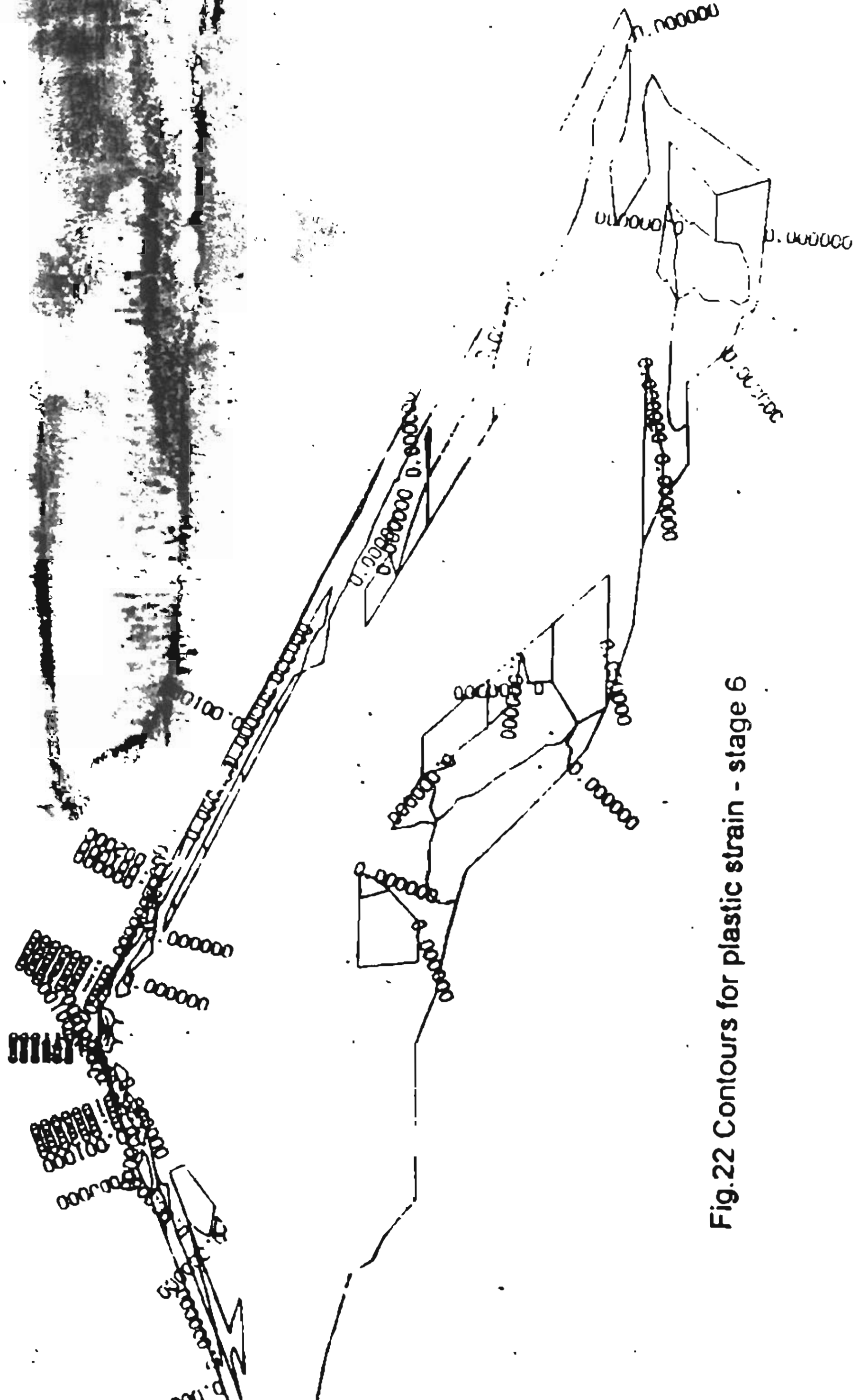


Fig.22 Contours for plastic strain - stage 6

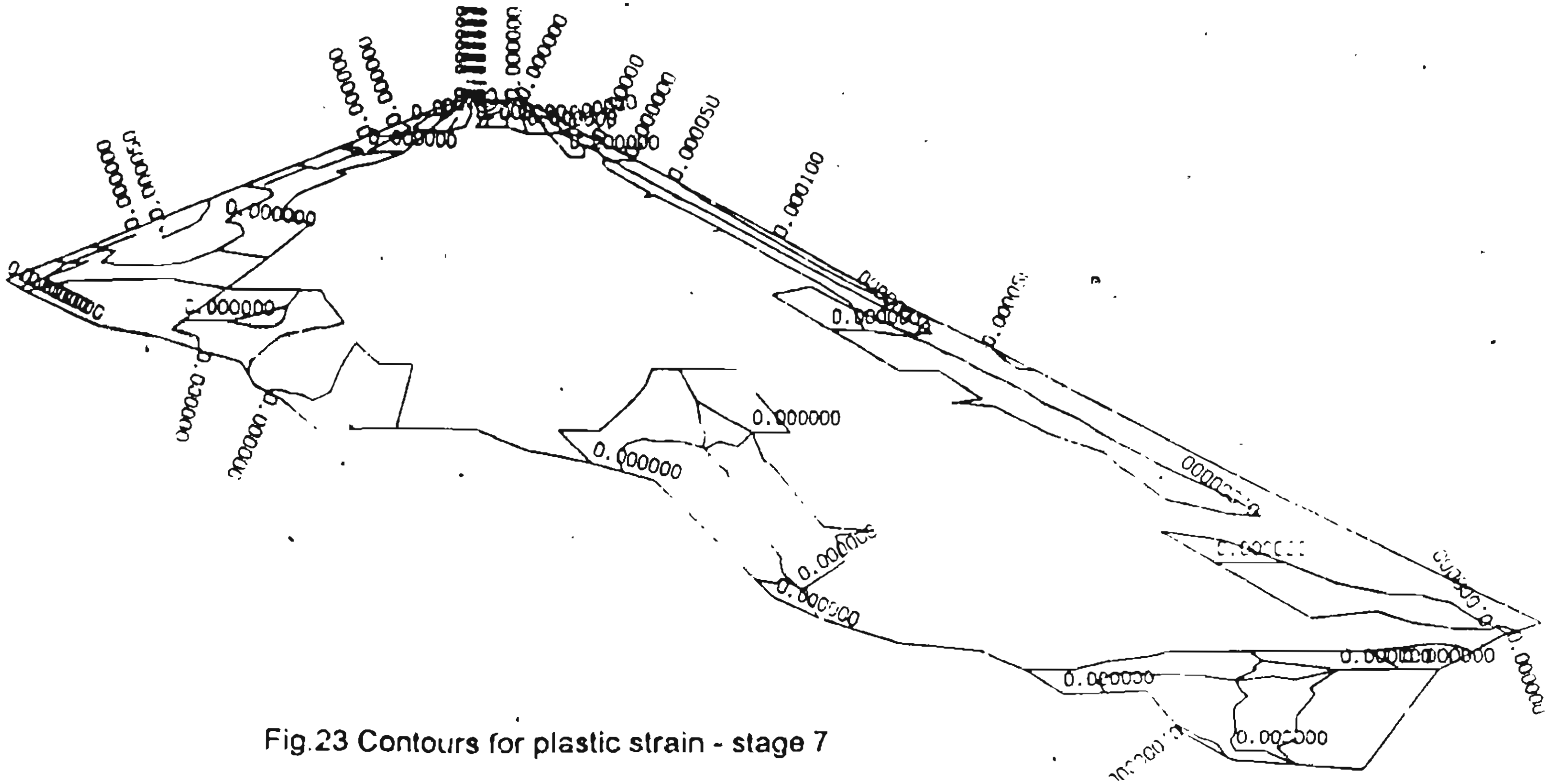


Fig.23 Contours for plastic strain - stage 7

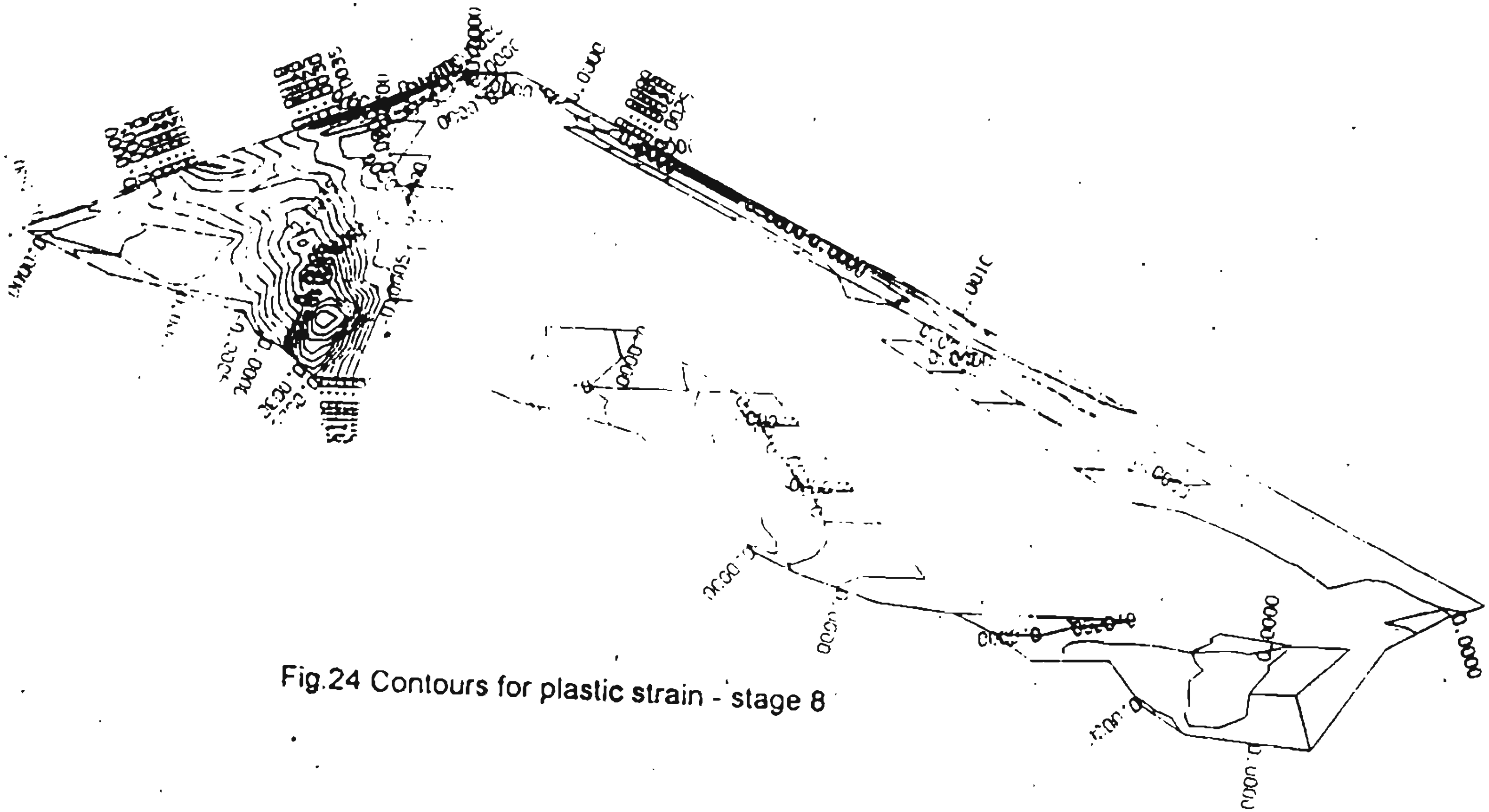


Fig.24 Contours for plastic strain - stage 8

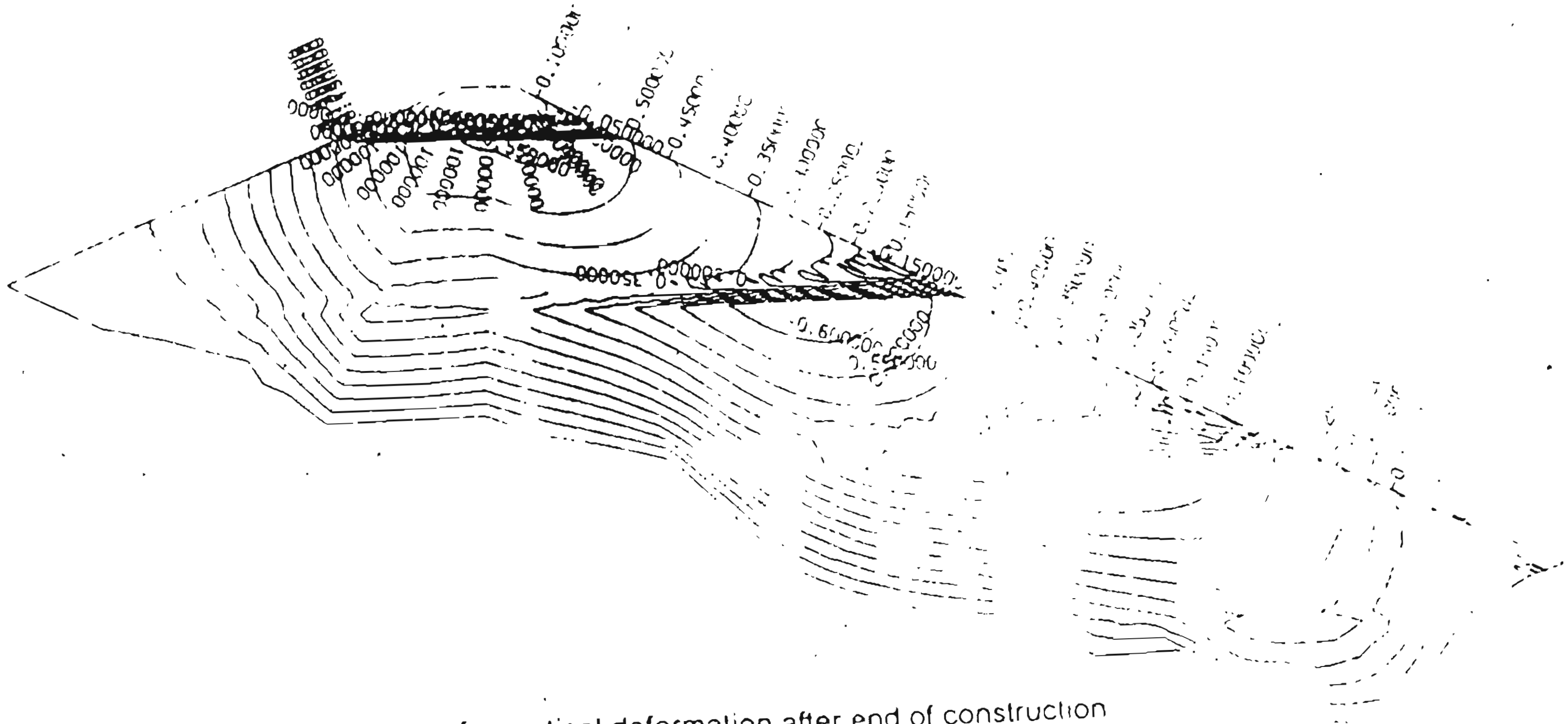


Fig.25 Contours for vertical deformation after end of construction

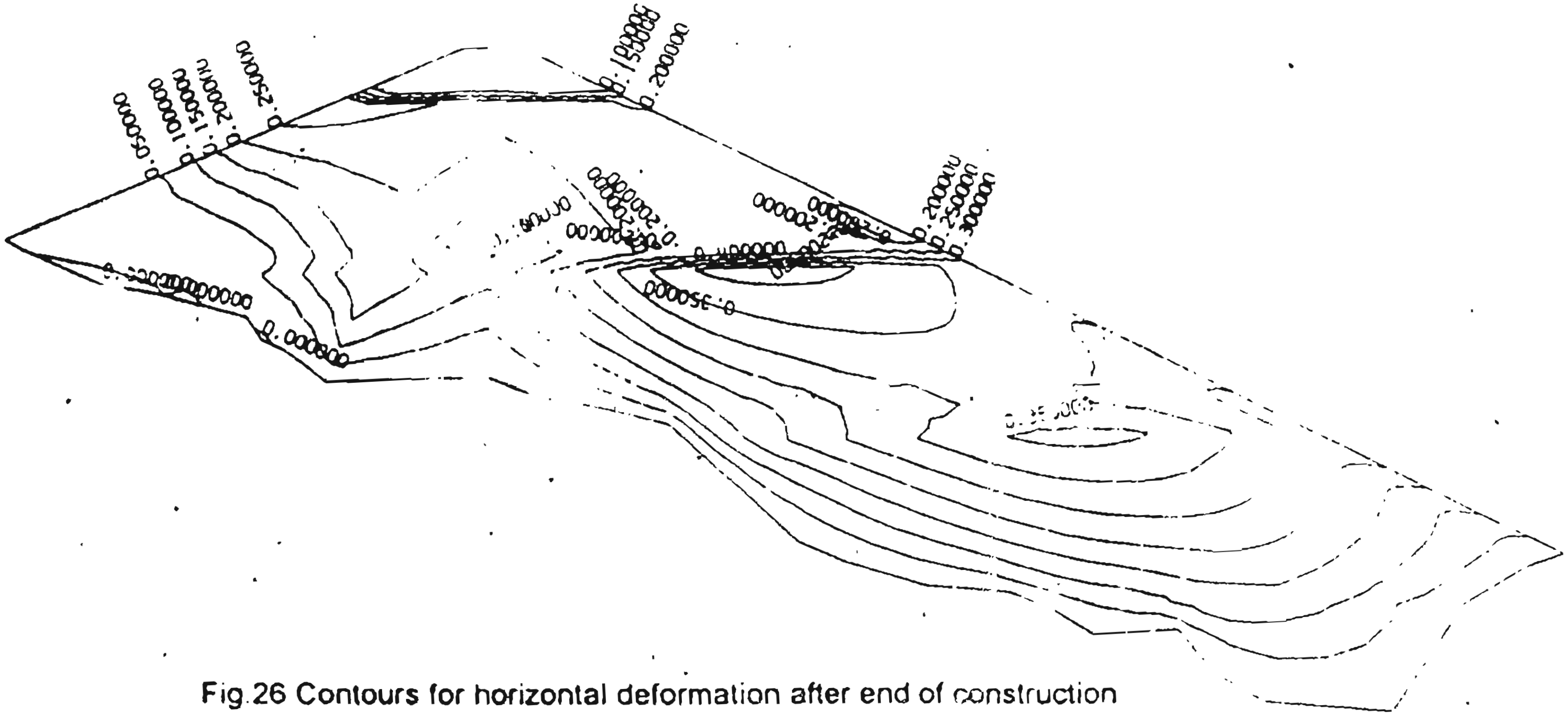


Fig.26 Contours for horizontal deformation after end of construction

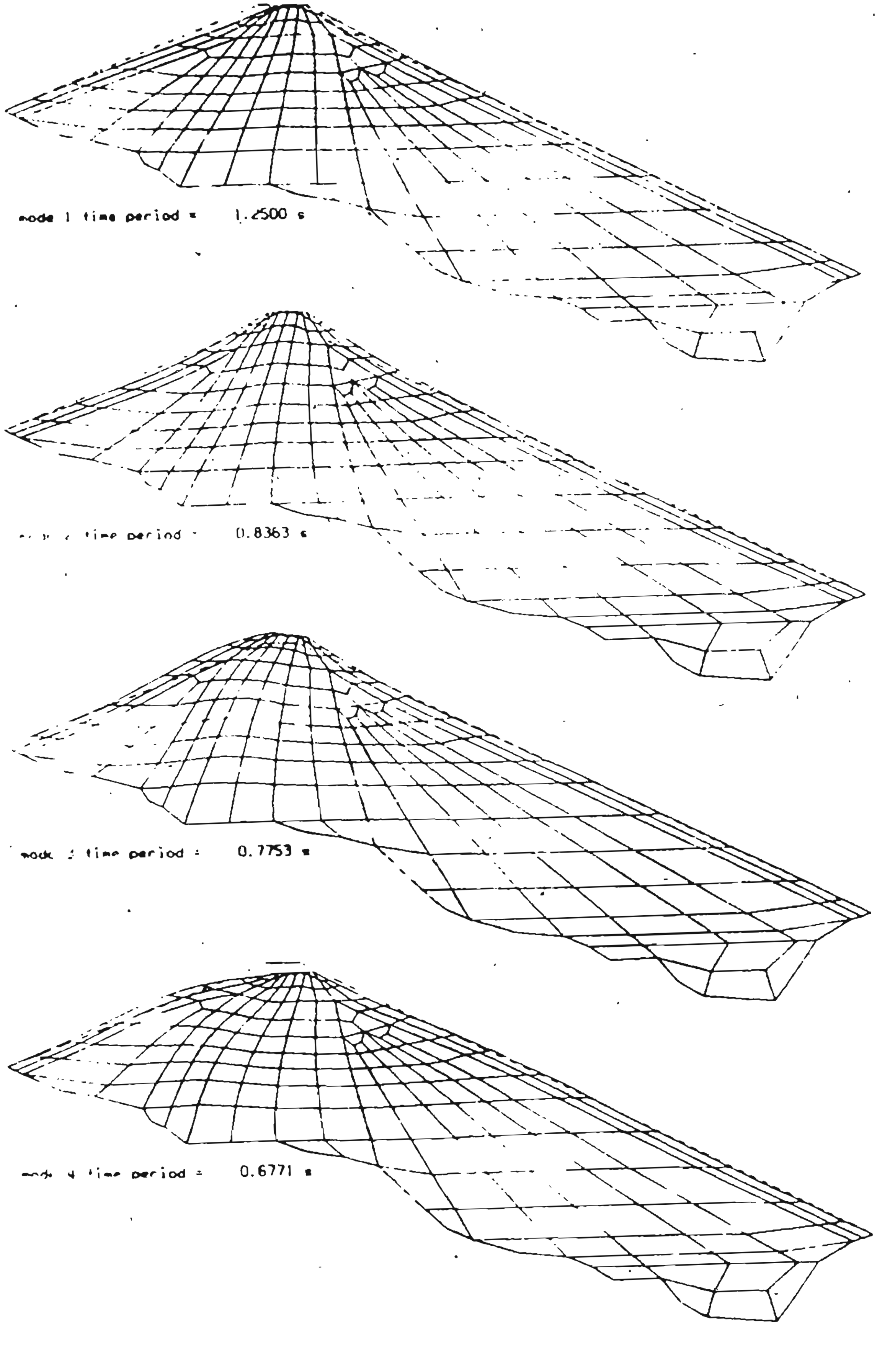


Fig.27 First four modes of vibration of the dam

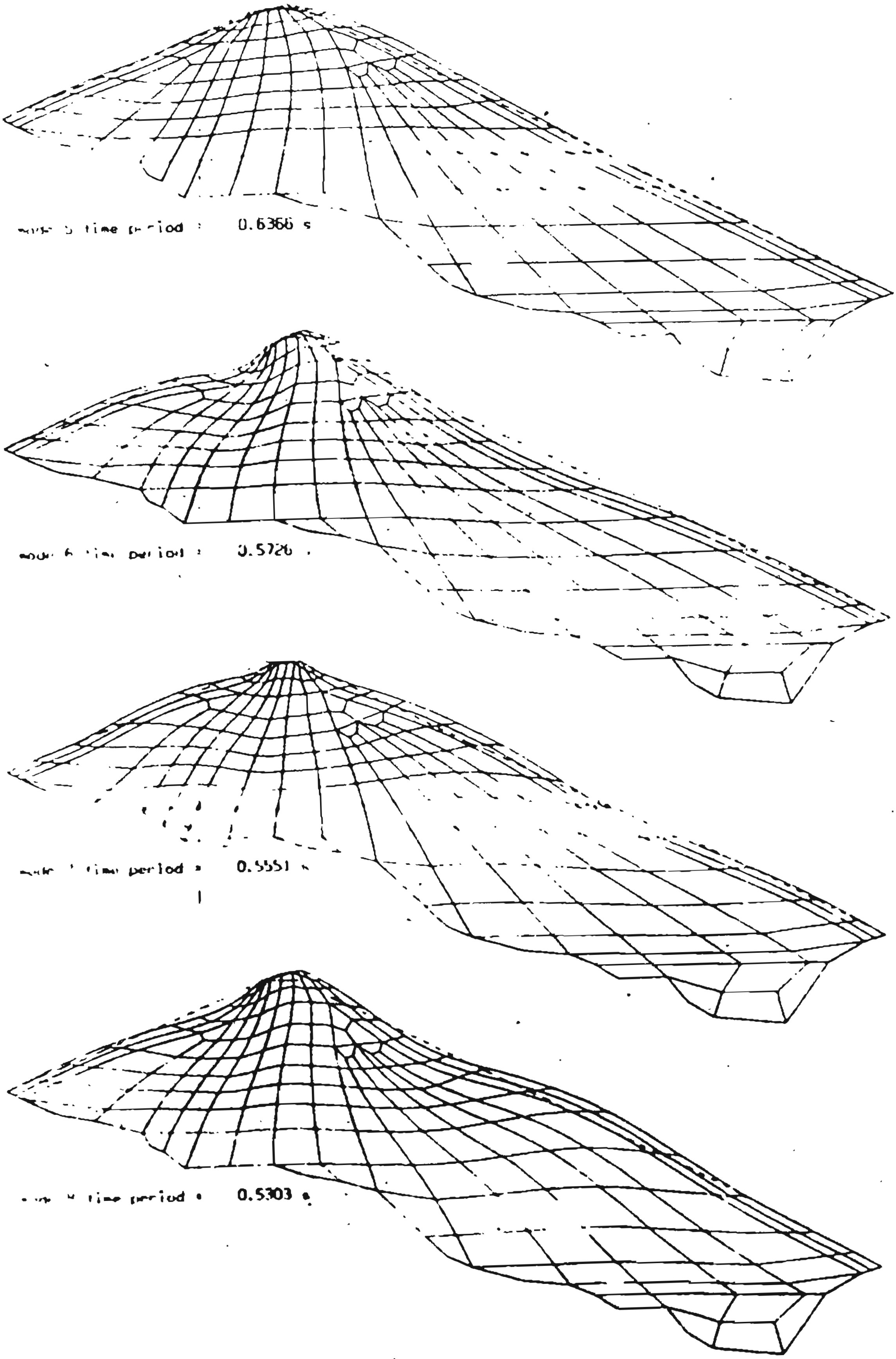
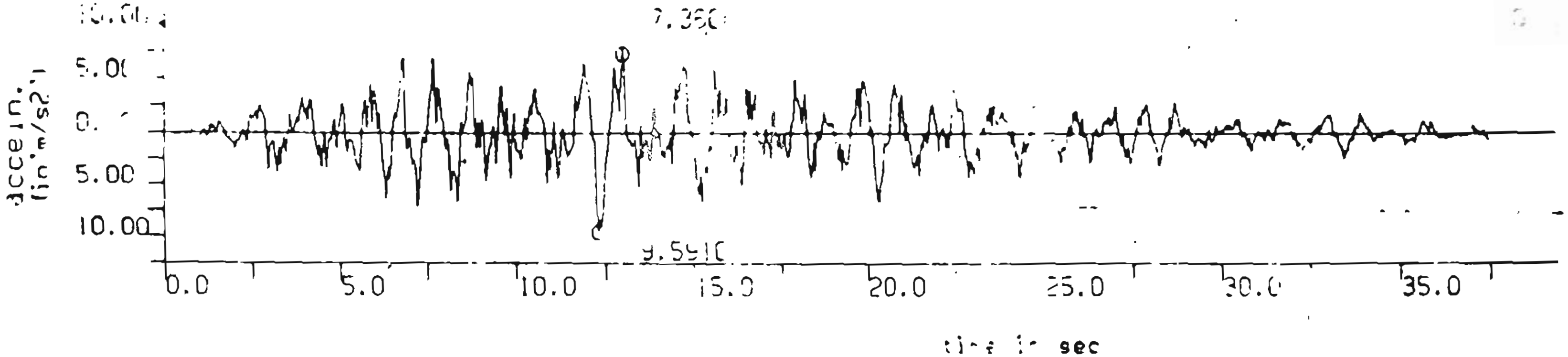


Fig.28 Five to eight modes of vibration of the dam



(c) Horizontal acceleration at crest

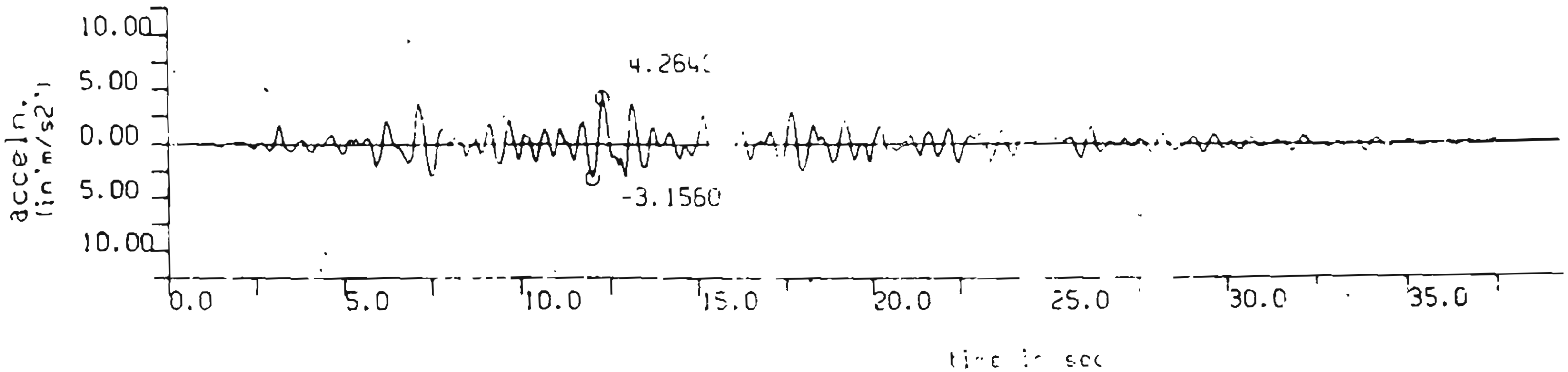


Fig 29 Time histories of horizontal and vertical acceleration at crest - nonlinear dynamic

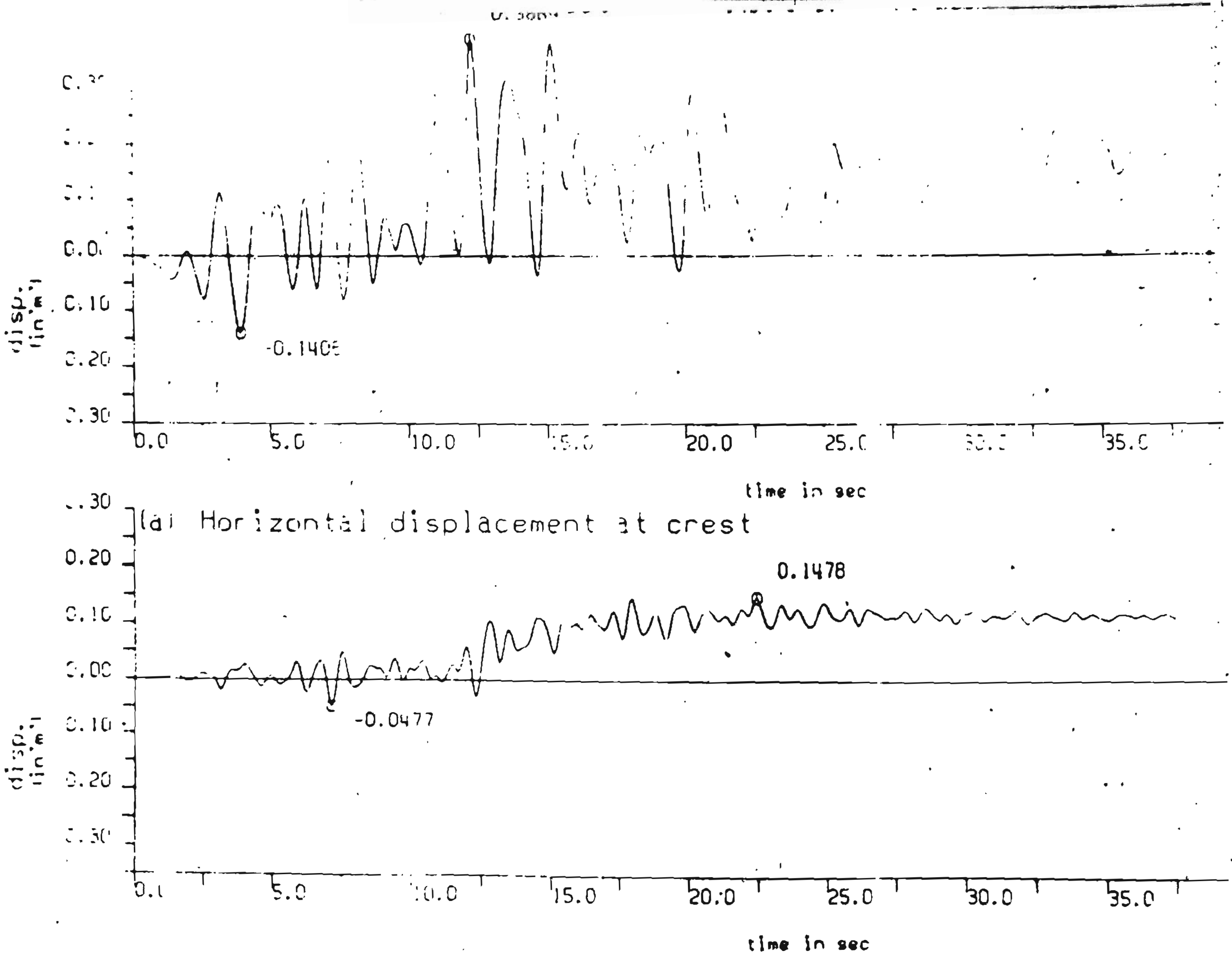
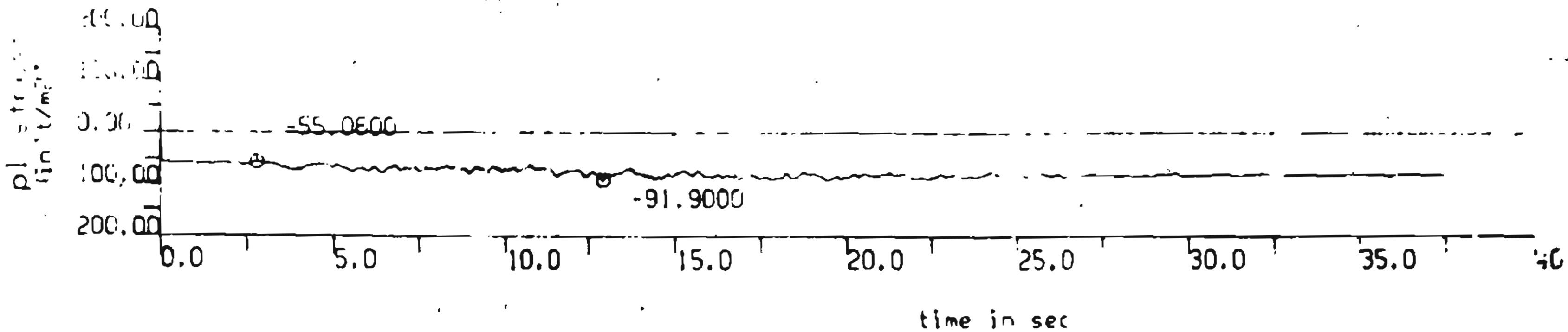


Fig.30 Time histories of horizontal and vertical displacement at crest - nonlinear dynamic



(c) P1 - stress history at the base of core (heel)

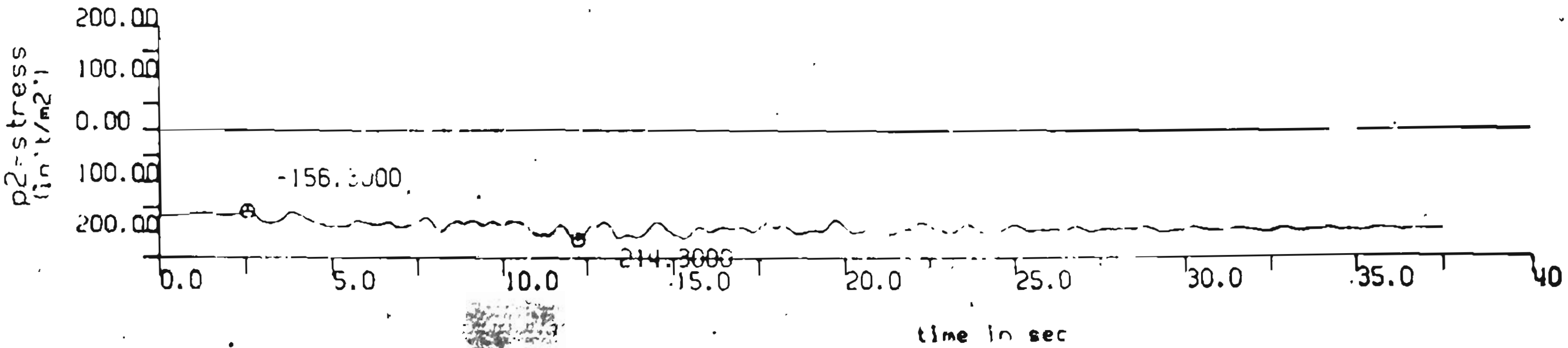
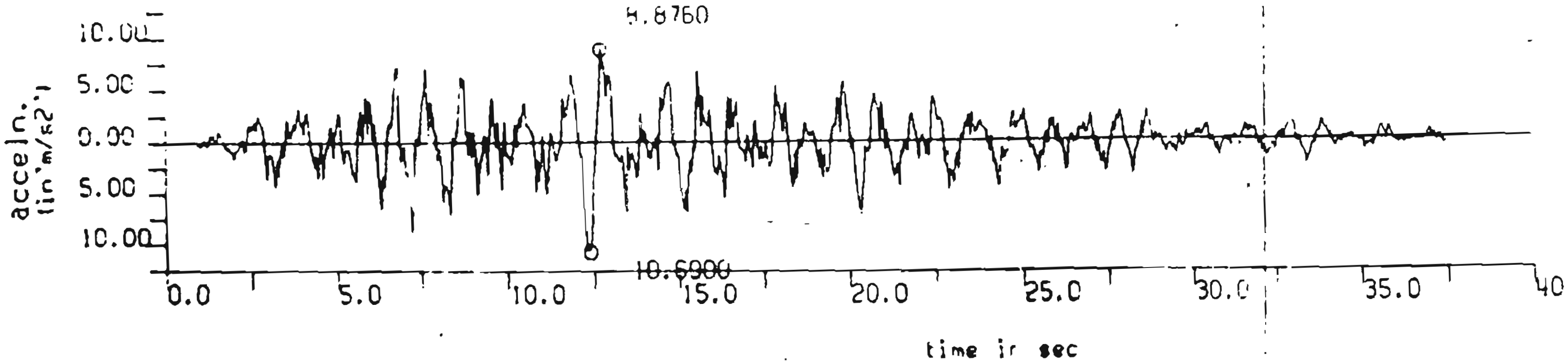


Fig.31 Stress history at the base of core (heel) - nonlinear dynamic



(c) Horizontal acceleration at crest

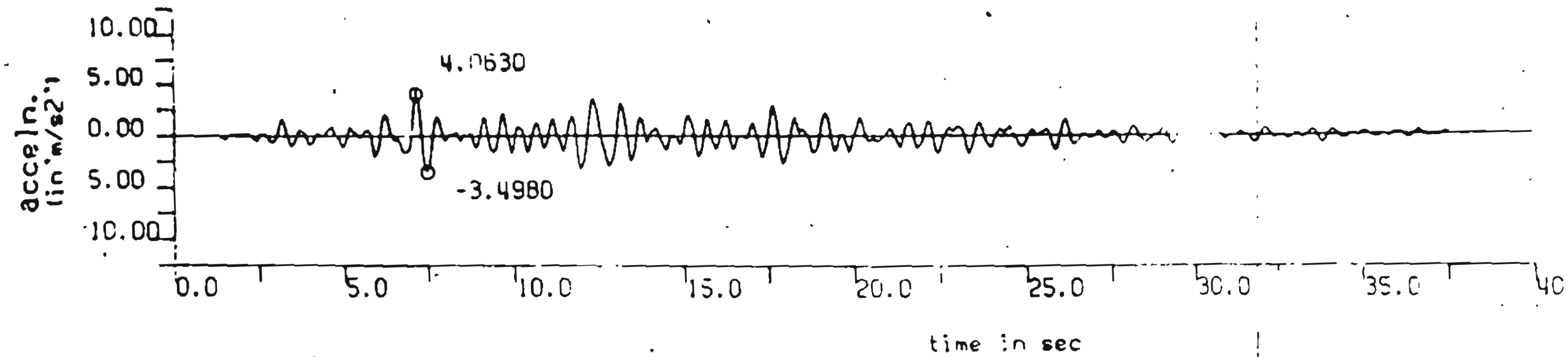
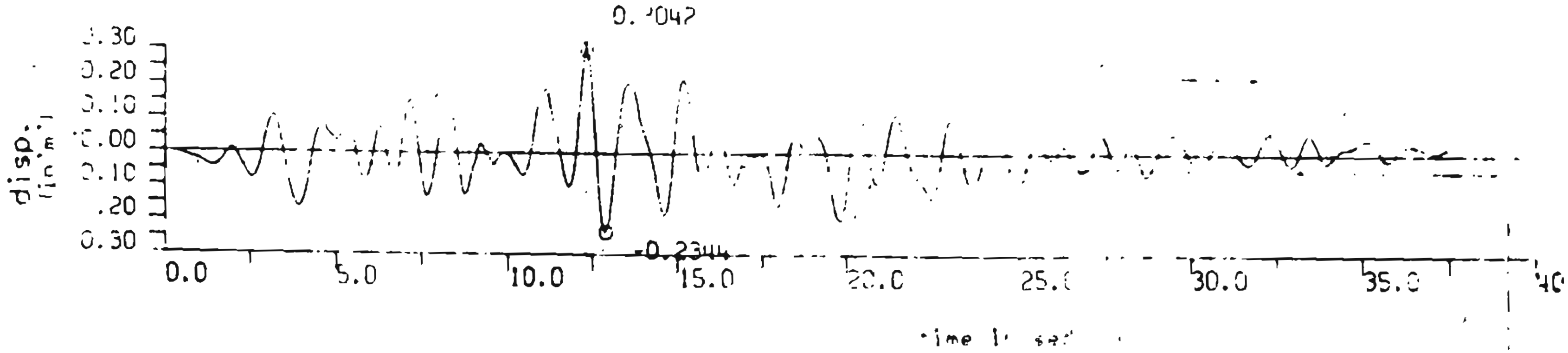


Fig.32 Time histories of horizontal and vertical acceleration at crest - linear dynamic



(a) Horizontal displacement at crest

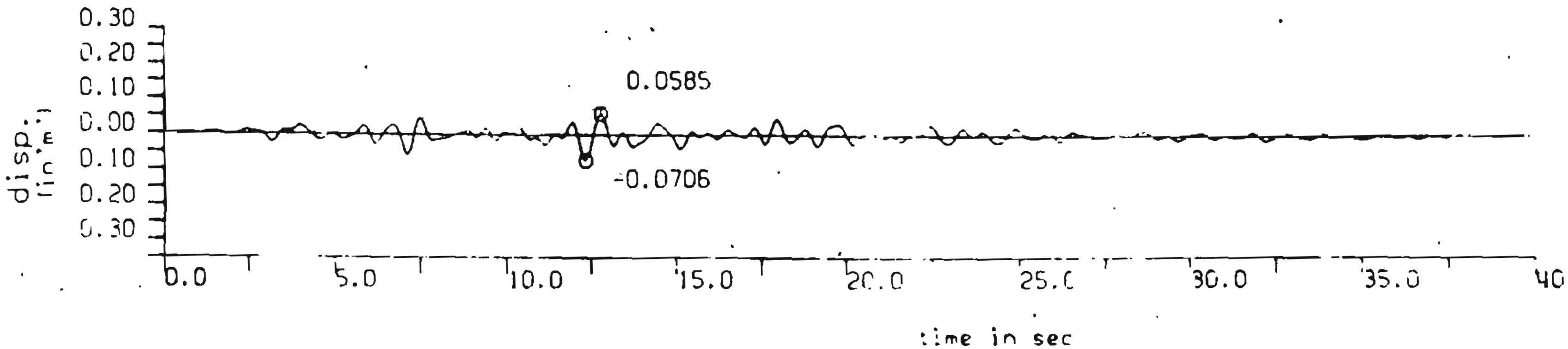
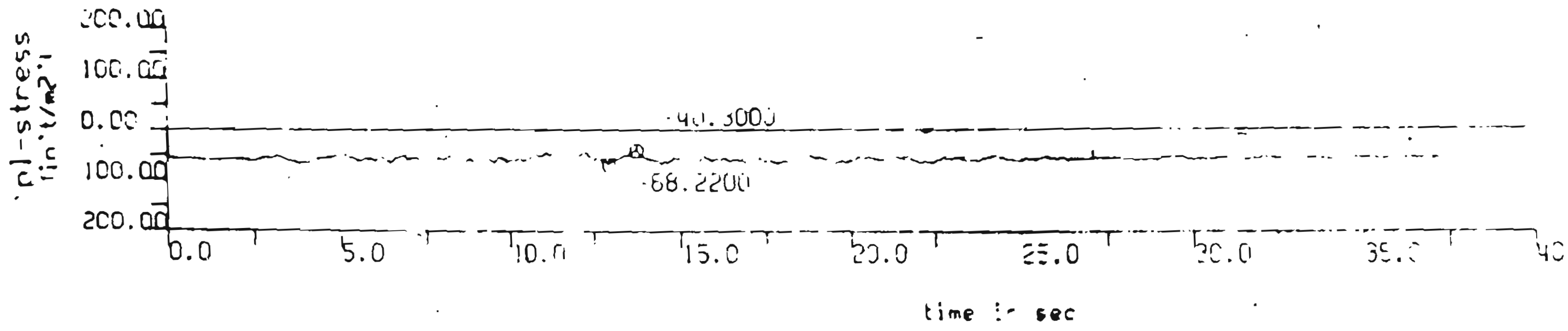


Fig.33 Time histories of horizontal and vertical displacement at crest - linear dynamic



(c) P1 - stress history at the base of core (heel)

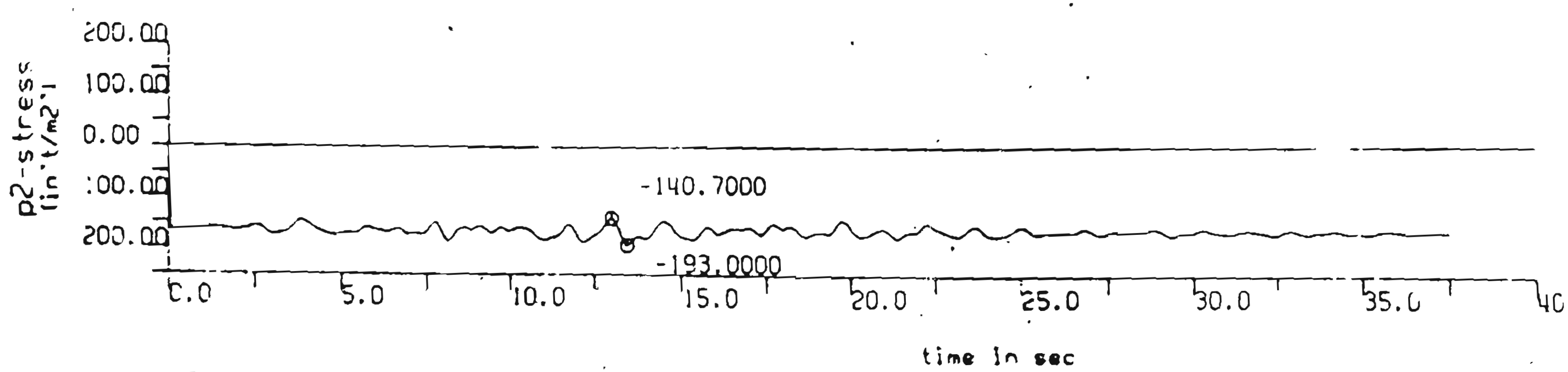


Fig.34 Stress history at the base of core (heel) - linear dynamic

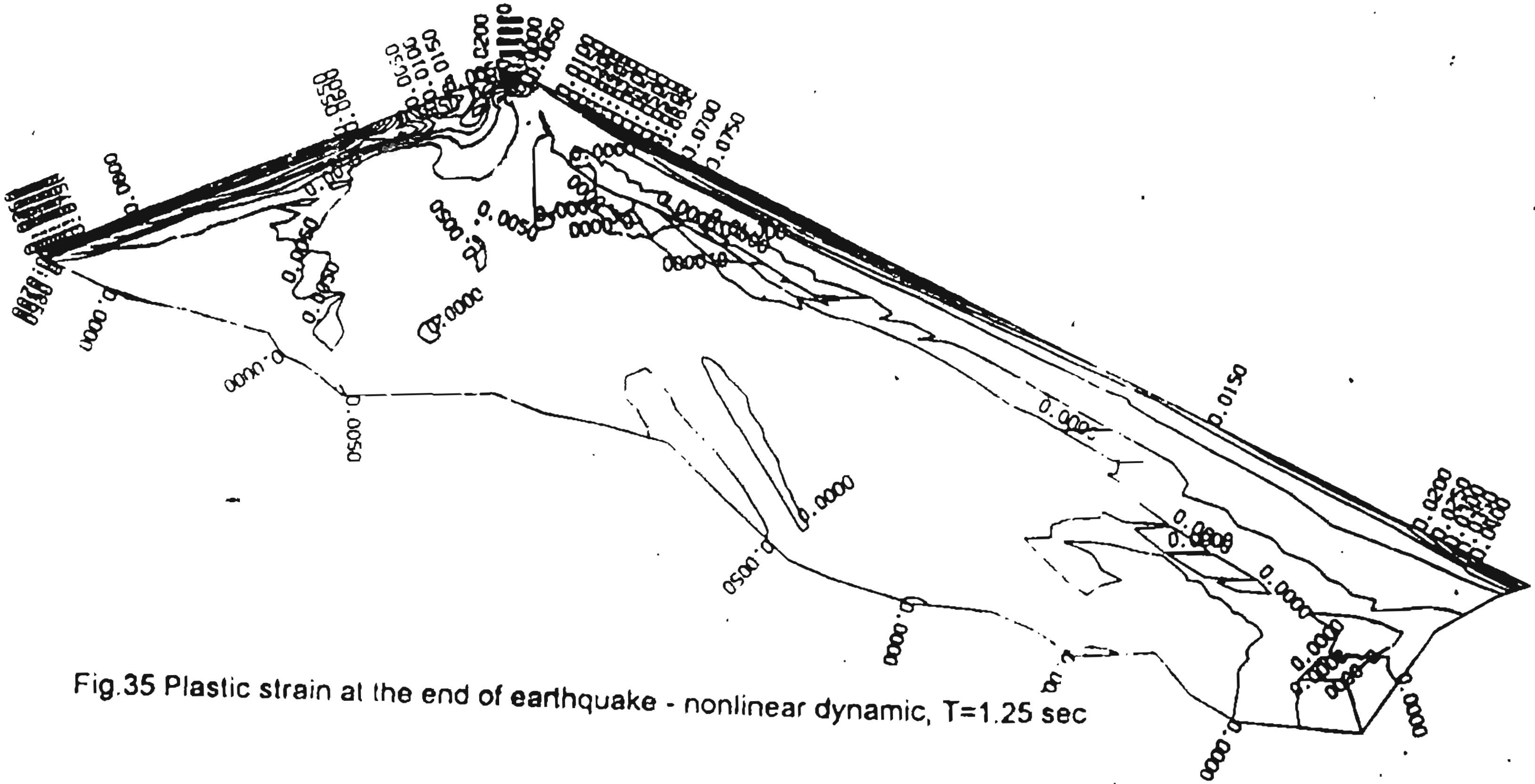


Fig.35 Plastic strain at the end of earthquake - nonlinear dynamic, T=1.25 sec

mulated Accelerogram in m/s2, sampled at 0.02 sec, total ordinates = 1901
ak ground acceleration = 0.5g or 4.905 m/s2

0000	0.0060	0.0120	0.0140	0.0180	0.0260	0.0360	0.0260	0.0300	0.0540
0940	0.0820	0.0660	0.0980	0.1120	0.1040	0.1700	0.1940	0.2180	0.22[illegible]0
1200	0.0380	0.1580	0.1180	0.1340	0.1560	0.1120	0.0340	0.0860	0.1620
3221	0.2741	0.1980	0.3161	0.5141	0.2060	0.0120	0.0920	0.3081	0.19[illegible]
2320	0.2000	0.4061	0.4881	0.3781	0.3181	0.5321	0.5241	0.6381	0.5901
8742	0.9622	0.8002	0.4681	0.5861	0.2400	0.1520	0.1620	0.5221	0.81[illegible]2
7522	0.6521	0.9082	0.1840	-0.3321	-0.0060	0.6921	0.5121	0.3641	0.0240
4161	[illegible].9022	0.9482	0.5001	0.7702	0.7422	0.0920	-0.3921	-0.4781	-0.48[illegible]
1560	-0.1580	0.1180	0.6961	0.3141	-0.2140	0.5761	0.5441	0.2320	0.4441
5561	0.5141	0.2280	0.0200	0.6781	0.7962	0.5661	0.4301	1.1062	1.33[illegible]
8042	0.1180	0.2000	0.9582	0.9462	0.0780	-0.3621	0.6081	1.1722	0.7021
2060	0.1160	0.1940	-0.2000	0.8042	2.3605	1.9904	1.8904	1.6123	0.82[illegible]
1080	0.0100	-0.0980	1.1402	0.9942	0.0200	0.4061	0.3081	-0.4641	-0.4581
7942	-0.0780	0.1640	-0.7221	-2.2165	-0.4801	0.2541	-0.8382	-1.5643	-0.78[illegible]
6541	-0.5901	-1.0222	-0.7702	0.4101	1.3663	1.3143	2.6725	0.9942	-0.0380
5381	-0.5061	-1.0502	-1.3103	-2.0544	-1.3423	-0.6201	-0.1800	-0.0860	0.752[illegible]
9122	0.6901	-1.4663	0.2781	1.4943	1.2383	-0.2481	0.3221	0.8362	0.6201
0540	0.6261	2.0924	3.0766	1.0842	0.3081	-0.8602	-0.9862	-0.5661	1.766[illegible]
1502	2.0844	2.5385	1.4943	2.1384	1.8684	-0.4261	0.7662	2.2205	2.2085
7802	0.7922	0.4001	1.5003	-0.1660	-0.0540	1.7724	1.6663	-0.0780	0.062[illegible]
2345	2.9566	2.3325	1.7143	-0.0620	0.5441	-0.1960	-0.7642	-1.0682	-0.1860
1760	0.3321	0.5161	0.6161	1.0002	0.2961	1.4843	1.1762	-1.5003	-0.918[illegible]
5481	2.8626	2.2024	-0.1200	-0.0160	0.1940	-1.7043	-2.5545	0.1460	0.2601
9222	0.5121	-0.6881	-0.2501	-0.5141	-2.0464	-2.7506	-0.5121	-0.0020	-1.664[illegible]
7864	-3.5627	-1.7384	-0.4821	0.8022	2.0924	2.4525	-0.5421	-0.4481	0.3781
1726	-4.4629	-3.0486	-2.6325	-1.6283	-3.5347	-1.7924	-0.1520	1.7684	-0.008[illegible]
9642	-1.5983	-1.0382	-0.9982	-1.2403	0.0500	1.2763	0.1380	-0.3641	-0.5101
6285	1.2823	1.3663	0.1960	1.3463	0.5801	0.6341	2.5165	1.6003	-0.5941
5581	0.1720	-1.5023	-3.4087	-2.7146	-1.8084	3.2607	0.8142	-0.3381	-0.5521
3723	-1.7204	-2.0604	-1.8144	1.4023	3.4407	1.5243	-0.5561	1.7764	-0.5401
4721	-0.2300	1.0102	-1.1462	-1.7424	-2.4305	-2.4365	-0.5941	-0.7942	0.4961
5783	-0.3681	1.8424	3.1026	4.4729	2.6265	1.6903	0.6821	3.2707	3.8928
6063	0.9822	0.7782	2.1044	-1.2423	-2.8946	-2.6825	-2.3705	-1.7023	-1.5463
3921	-0.2280	-0.4161	-0.7642	-1.7944	-0.8362	-2.7226	-3.0046	-3.3527	-3.7428
0588	-1.7143	1.3783	1.2483	4.0708	2.2665	-0.1140	0.5101	-3.2587	-3.4707
3921	3.8248	0.6421	-0.7121	-1.6983	0.0860	1.6323	-1.0242	0.2140	1.8564
7043	1.6043	0.6781	0.9882	-1.6183	0.0240	-1.7003	-1.2142	-0.6741	0.2160
0082	1.9644	2.5585	1.2423	0.9502	1.4683	0.5241	0.2000	-1.4963	2.0484
8704	-3.2947	-3.2567	-1.3263	-0.1640	-1.4503	-1.8064	0.8462	0.9942	-2.4705
8488	-2.1284	-2.3045	2.9846	0.7241	-0.2521	-1.1122	-0.1920	-0.8402	0.5441
7184	-1.1082	-1.8464	-1.6643	-2.9566	-0.9142	-1.0582	2.3205	3.0006	2.4945
9404	0.7922	-0.2781	-3.1606	-0.8302	0.8762	2.9686	3.1646	0.9402	1.3443
8102	1.1182	-2.8886	-2.8946	-2.7966	0.9962	0.8082	0.1960	1.5003	0.9262
2543	-0.4061	-1.3303	-2.3105	-3.8788	-1.0562	-0.9582	-0.8082	-2.9406	-3.2087
3721	-0.1280	2.0284	4.2249	4.7150	2.4665	2.2845	0.0300	1.7564	4.4969
1460	-0.2901	-1.5443	-1.8024	-1.8044	-3.0406	-1.6223	1.5963	3.5927	-0.4141
9042	0.5661	-0.1760	1.7003	2.1384	1.0942	-1.1042	0.9422	1.1042	0.8142
1722	-0.2841	4.1528	3.2727	2.2745	-0.6281	-1.9464	-2.6465	-2.7366	-3.3007
1326	0.3621	0.2340	-0.5101	0.9222	1.3723	3.3547	-2.7446	-2.3045	-1.0142
1482	2.6345	4.5569	3.5387	1.2463	1.1502	-0.8142	-1.8744	-0.7442	-1.2162
5085	1.4643	1.0382	-2.2265	1.0362	1.5743	2.6925	2.5145	-1.7204	-0.4921
2383	-2.0524	-1.5083	1.0422	2.5705	0.2881	2.2765	-0.4501	1.6983	-0.4921
5823	0.1700	0.6081	0.7882	-0.3541	-1.6343	-2.1864	-1.4263	1.7764	-0.4241

1180	-2.6225	-1.9364	-2.6625	-1.6043	-3.2547	-3.0026	-2.5865	-1.2723	-1.06
6805	-0.6061	3.1506	-0.1220	-0.0020	-2.0224	-0.0660	0.9042	0.8082	-0.52
5603	-4.3629	-4.7790	-3.4907	-3.4587	-2.2785	2.0184	-0.1160	0.8742	0.30
5041	-3.2407	-2.4605	-3.4927	-4.5549	-0.7582	-0.7962	-0.8602	-2.3585	-0.90
4065	3.9668	1.4923	-1.1262	2.1124	0.2120	0.3441	1.5963	0.4561	2.78
2002	-0.2821	-2.9846	-1.9404	-2.2004	-2.3545	-2.5065	-2.5105	-1.4103	-3.25
6363	-0.3781	-1.8404	-1.2303	-3.4767	-2.3085	-4.1448	-1.7664	-0.6241	-0.34
3087	-3.2067	-1.8384	-0.5061	-1.3163	-1.3283	-2.0844	-1.7784	-2.5405	-2.75
3349	-1.4543	0.5841	1.6383	3.1186	2.2044	1.5503	0.9822	-0.2961	0.74
8586	2.9826	1.3743	3.7508	-1.1022	-1.4183	-1.7504	-0.5181	-1.9284	-1.33
0680	-0.8442	-0.2581	-0.8362	-0.6801	1.9844	-0.2921	-1.4663	-4.3969	-1.1
2262	3.5947	0.9062	1.5423	3.2707	2.0544	1.3163	-1.0682	-1.8224	-2.45
1426	-2.3405	-2.9406	-1.5683	0.0220	2.8766	0.8722	0.7982	0.3641	-1.58
2961	-0.9242	-0.8042	0.4561	-0.1140	-1.5083	-3.8188	-1.4383	-1.2242	1.9
7021	-0.4561	2.5645	0.6901	-3.4407	-3.9228	-0.9702	-0.6401	0.5981	-0.9
9926	-4.1688	-3.4507	-4.1188	-3.4867	-3.9368	-2.6025	-1.7484	-0.0220	-0.6
3921	-1.0342	-1.1662	-1.5043	-2.9326	-2.6045	-1.6143	0.5161	-1.2202	-1.7
2501	-0.1660	-0.9662	-3.2127	0.7221	0.8702	0.7141	0.1940	-0.5641	0.8
1784	1.2363	0.1720	0.6761	0.3941	0.7021	2.2405	-0.5161	3.4307	3.7
8868	3.3307	0.5681	-3.6167	-2.8826	0.3581	0.4161	1.1082	2.9466	1.4
9002	-1.9904	-0.7241	-0.4921	0.5161	-3.2407	-2.6465	-1.8824	-2.7706	-1.6
7784	-1.1942	2.3385	2.1124	1.3703	-0.1640	1.3623	-0.2741	0.0320	-2.1
3123	-1.7324	-0.5741	2.3165	1.1282	-0.6981	-0.4461	-0.6401	-0.5541	-3.3
7826	-2.1884	0.5801	-1.1282	-0.8202	-0.5801	-0.9822	-0.6501	0.1800	0.9
0884	2.8366	-0.0760	-1.9084	2.3905	1.0522	0.9002	-0.8142	-3.2047	-4.5
6790	-4.9050	-3.0566	-0.9682	-1.0662	1.4043	1.1202	-2.6665	-2.1244	-0.8
0782	0.4241	0.5881	-0.1240	0.2541	1.0522	-1.5963	-2.1764	-1.6203	-0.3
4561	-0.3301	1.2883	2.3165	1.8444	0.2300	1.9064	1.7564	0.4201	0.1
0742	0.8982	0.2721	0.9082	1.0002	-0.3601	-0.2581	2.9786	3.9108	2.4
6323	-0.9762	-1.8924	-0.4301	-2.4905	-1.6303	0.0240	2.4325	0.5381	-0.4
2683	0.1420	1.3883	-0.6521	-1.3023	0.1100	-1.8124	-1.6843	0.7121	2.8
4965	4.7670	2.0524	1.7544	1.1642	0.1440	0.0600	0.0980	-0.0760	1.1
0902	0.6081	-1.6363	-2.3585	-2.5945	0.8922	0.3201	-0.2380	-0.9442	1.7
3065	0.2260	-0.9082	-0.1980	-0.4301	-0.7161	-0.4961	2.0504	1.8164	3.4
2345	.2523	0.7522	1.5823	0.7902	2.3585	2.5585	0.9242	0.7101	-0.1
7482	1.9684	1.4143	2.8326	2.8006	0.4941	-1.3043	1.9264	2.2165	0.4
4781	1.4203	2.0324	1.2963	-0.8602	-1.2583	0.0160	1.3503	0.3161	1.2
4441	0.8422	1.8264	1.4323	2.1844	2.8126	1.0842	-0.7642	-1.3543	-2.7
2867	-2.0524	-0.4921	1.1002	0.6401	2.6525	4.2409	2.4665	1.8664	1.7
6703	0.3401	-0.6461	-0.3141	2.5785	3.2387	0.8262	-1.2042	-2.1704	-1.7
7001	-1.0982	-1.2783	-0.4081	0.1380	-2.5545	-1.3543	-1.0702	-1.9944	-0.5
2042	0.2701	0.2080	-0.5141	-0.5081	0.2140	-0.4221	-1.1182	1.0622	-0.9
2845	-2.6145	-1.2222	-0.5081	0.4221	-0.1880	0.2641	1.2483	1.1102	-1.2
6981	0.9462	2.1284	0.2881	0.0280	0.0160	1.8224	1.8264	3.3047	3.2
2805	1.9824	2.9306	2.7206	2.5145	0.4421	1.0482	1.1342	0.5501	0.3
3165	1.2823	1.6983	0.0140	-1.7043	-0.6521	0.5861	-0.6521	0.9622	3.2
8948	1.5003	-0.2821	-1.7604	-0.5341	-1.0482	-1.3143	-0.1760	1.4303	0.4
1442	1.2403	-0.2420	0.2741	1.5603	0.4001	0.1360	-1.7444	-2.1844	-0.5
2242	0.9922	1.1562	1.1582	2.0844	1.7744	0.8522	1.9764	2.7826	1.1
1781	-0.6621	0.6601	-0.1680	-1.5523	-1.4323	-0.3541	-0.3541	0.3661	0.2
2821	0.7782	1.1742	0.3821	-0.9102	-0.5761	-0.8222	-0.4561	0.9182	-0.5
3404	-0.8682	-0.8422	-0.3601	-0.8482	-0.9702	0.9802	1.7564	-1.8184	-2.3
5803	-1.9664	-1.4583	0.3361	1.3323	1.4703	-0.2380	-1.9824	-2.5985	-1.1
5323	-1.3323	-1.3643	-0.6761	-0.0440	0.9742	0.6201	1.3203	0.8822	0.2
3482	1.2002	-0.4641	0.2961	1.1622	2.3685	-0.0480	-1.4043	-0.8122	-0.1
9304	-2.0744	-2.2625	-1.5023	-0.7341	-0.6981	-0.4221	1.5383	0.8362	0.6
0140	0.4501	-0.0940	0.1440	-0.5201	0.7181	2.0204	1.3903	0.5021	1.5
5321	0.8442	3.0806	3.8968	1.3563	0.6301	-0.7902	0.3861	0.6121	-0.2
3882	2.8546	2.2805	1.4123	0.7001	1.1102	2.1144	2.7046	1.3963	1.9
2003	1.0262	-0.5461	-0.1860	-0.0200	-0.9742	-1.0522	-0.0900	0.8442	0.8

6561	1.2303	-0.0400	-0.9242	-1.1642	-0.6561	-1.0262	-1.3043	-0.9662	1.1562
2485	0.5281	0.4681	0.6121	1.3643	2.1844	0.1780	-0.0441	0.6281	0.5741
4501	0.7362	1.5343	0.6141	-0.0540	-1.4583	-1.3643	-1.4383	-0.9262	0.1200
6503	1.1322	-0.1380	0.6361	0.4181	-0.0700	1.1682	1.1982	1.4403	0.6881
2801	-0.7882	1.0922	0.4901	-0.3961	-0.4521	0.6901	1.5323	-0.2160	-1.5803
4241	[illegible].0860	0.3001	-0.1320	0.9982	0.9442	1.1802	0.6201	1.2403	0.2000
0762	-[illegible].1762	-1.0022	-1.0822	-0.5321	-0.3441	0.0520	-0.4281	-0.2340	-1.7604
1360	0.9162	0.1980	-0.1400	0.5521	-0.0340	-0.8782	-1.9864	-1.4523	0.3621
3281	-2.8346	-1.2763	-0.8202	0.4401	1.0442	1.7023	1.1562	0.9642	0.1260
8502	-0.9502	-1.0282	-0.9702	0.4941	1.1302	1.3243	0.1520	0.4781	0.1520
6121	-0.5621	-0.3441	0.8642	-0.0160	-0.9582	-0.5741	-0.6781	1.0162	-0.3721
1200	1.1162	1.4523	0.3441	0.7522	0.3601	0.8322	0.6961	-0.8442	-0.2400
3361	0.4801	0.4461	-0.1140	-1.0982	-2.0284	-1.2723	-0.5441	1.0042	0.6401
0840	1.0942	1.3423	0.1280	0.2841	1.5443	0.9962	0.5581	0.5201	0.3741
5603	0.9122	0.3421	1.2823	1.7304	0.9182	-0.4221	-0.7442	-0.8582	0.4841
2280	-0.0660	0.2901	-0.0560	-0.7802	-1.3223	-0.7742	-0.9962	-0.9602	0.5161
8082	0.2861	-1.2082	0.0520	0.3041	0.0040	-1.0562	-0.7482	0.1200	0.7061
6621	0.4761	1.0202	0.1820	-1.6803	-1.3043	-1.6603	-0.1660	-0.6301	-1.2283
6941	0.7482	0.0580	0.3321	1.8304	1.8404	1.7464	1.7584	0.7782	0.3281
0702	-0.3581	0.1400	1.0062	-0.3861	-0.0200	0.9922	0.6161	0.1120	-0.0580
2781	1.1942	0.7702	-0.3361	-0.6161	0.8762	0.0680	0.4901	0.3701	0.9522
1200	-1.3443	-0.7782	0.0840	0.2280	0.1080	0.1260	0.3081	-0.2340	-0.1260
5481	-0.0960	-1.4983	-1.2983	-0.2901	0.1940	0.3341	0.0180	0.4521	0.5681
3881	-0.9122	-1.4243	0.8282	0.9542	0.4821	0.2921	0.7442	0.3281	-0.1120
3681	0.1340	1.4603	0.3261	0.6401	1.2543	0.2601	-0.1020	-0.2741	0.0320
1380	-0.0480	-0.7161	-1.1142	-0.9682	-1.5083	-0.4481	0.3201	0.7842	-0.5481
9722	-0.2220	0.1280	-0.2340	-1.3403	-0.3341	0.4741	-0.2961	-0.3581	-0.0900
1802	0.5841	0.3421	0.0700	0.2260	-0.5561	-0.5561	-0.0900	-0.3301	0.3581
3401	0.5381	2.0144	1.5823	1.5023	1.0882	1.2403	-0.0760	-0.1500	0.0200
7221	0.9382	0.0600	0.5221	1.4263	0.3761	-1.0622	-0.7802	1.0062	0.7021
3063	0.2461	0.1660	0.0520	-0.6401	-0.7962	-0.1800	0.0020	-0.2320	-0.0880
1080	0.2020	0.7181	0.1960	1.4383	0.9222	0.3881	-0.2501	0.2420	0.3661
5601	-0.5501	-0.0320	-0.2521	-1.2162	-1.3763	-0.1280	-0.4021	-0.5721	-1.3063
3221	0.2200	0.3861	-0.3081	-0.3441	0.5341	-0.0260	-0.1660	-0.2901	-0.5961
0380	-0.4881	-0.1720	0.0720	-0.2320	-1.4683	-0.4521	0.0660	-0.7822	-0.6541
3722	-0.8722	-1.5643	-1.8344	-0.7902	0.4301	1.0202	0.2440	0.8062	0.5961
2040	-0.8062	-0.9442	0.0600	0.4801	0.2501	-0.5821	0.4001	0.7582	0.2020
2440	-0.0380	0.1580	-0.4201	-0.2941	0.3921	-0.1440	-0.3841	-0.2420	0.6201
1100	-0.1120	-0.4221	0.2821	0.5641	-0.2881	-0.0200	0.1800	0.0720	-0.2581
5401	0.0320	0.2080	0.2601	-1.0122	-0.0680	0.7802	0.4701	0.1380	0.4861
4621	-0.1900	-0.5801	-0.8462	-0.4221	0.0220	-0.6321	0.3781	-0.3501	-0.8962
7382	0.3441	0.7041	0.5861	0.1220	-0.2020	0.1380	-0.2941	-1.0762	-0.5761
1400	0.2461	-0.8302	-0.3901	-0.3261	-0.3581	-1.1322	-0.9722	0.2100	0.3901
1380	0.2360	0.5401	0.7121	-0.0180	0.0000	-0.3721	-0.3461	-0.8482	0.0760
3621	0.3481	0.6401	0.3161	0.7702	0.6421	-0.4621	-0.4781	0.1760	0.3321
7922	-0.8262	-0.7522	0.1920	-0.0240	-0.3821	0.1580	0.0760	-0.7382	-1.1982
1521	0.0120	-0.2060	0.0180	-0.4961	-0.1140	-0.3561	-0.5621	-0.3541	0.0740
1520	-0.2320	-0.0160	-0.6141	-0.8822	-1.3663	-0.8602	-0.0320	-0.6441	-0.8862
5221	0.1320	-0.2320	-0.8182	-0.2140	0.4761	0.5621	-0.2180	0.0900	0.0240
0740	-0.3241	-0.4961	-0.2100	-0.2701	-0.3001	-0.3121	0.3521	0.5161	-0.4141
3981	-0.8582	-0.6681	-0.6301	-0.2721	0.1820	0.4021	-0.3581	-0.3601	0.7101
2440	-0.4441	-0.1100	0.0040	0.2160	-0.6881	-0.7642	-0.5201	0.1540	-0.4021
1142	-0.7742	-0.9782	-1.1882	-1.2262	-0.8642	-0.1380	0.0480	0.1120	0.0060
3361	-0.4261	-0.5281	-0.3061	0.0380	-0.1580	-0.4681	-0.0860	0.0560	-0.3881
1420	0.5221	0.8542	0.1740	0.0360	-0.0840	0.7482	0.1140	-0.6081	-0.6361
4561	-0.3501	-0.4921	-0.4561	-0.0500	0.1080	-0.2781	-0.8142	-0.0940	-0.3201
3741	-0.0440	0.4521	-0.0920	-0.4721	-0.4381	-0.4021	-0.1200	-0.4641	-0.2801
4581	-0.0940	-0.3801	-0.3281	0.0020	-0.2521	-0.3921	-0.5841	-0.1220	0.2220
1481	-0.5041	0.1240	0.8562	0.6061	-0.0600	-0.0280	-0.2861	-0.4581	-0.6341
0940	0.1620	-0.1160	-0.0180	0.1120	0.1780	-0.3641	-0.4561	-0.2841	-0.2220

).6281	-0.7522	-0.1900	-0.2821	-0.3841	-0.7201	-0.9582	-0.4281	-0.8182	-1.128
).6521	0.0780	-0.4501	-0.8162	-0.7582	-0.3641	-0.0920	-0.5401	-0.5361	-0.132
).3881	-0.7602	-0.8662	-0.5861	-0.9782	-0.4481	-0.0700	0.1400	-0.0180	-0.450
).6001	-0.1720	-0.1600	-0.5141	-0.3901	-0.0220	-0.2280	-0.3001	-0.4821	0.448
).4981	0.0500	-0.1780	0.1300	0.0620	-0.4361	-0.6381	-0.1860	-0.1000	-0.536
).9002	-0.5901	-0.7281	-0.4201	-0.4761	-0.1820	-0.0540	0.1460	0.2020	0.458
).5001	-0.1760	-0.5561	-0.1480	-0.2320	-0.3201	-0.5121	-0.0320	0.3501	0.240
).5921	-0.2741	-0.1060	-0.6741	-0.6241	-0.1680	0.0580	-0.0020	-0.4781	-0.452
).1880	0.0520	-0.2521	-0.0420	-0.0260	-0.1880	-0.4961	-0.5641	-0.3761	-0.260
).2140	-0.1520	0.0580	-0.1800	-0.7502	-0.3401	0.0140	-0.1100	-0.6741	-0.626
).1160	-0.1380	-0.4761	-0.3901	-0.0640	-0.1940	-0.3361	-0.5041	-0.3141	-0.026
).4181	-0.3561	0.0320	0.1420	0.0140	-0.2240	-0.2300	-0.2020	-0.3201	-0.782
).5941	-0.4901	-0.7542	-0.5781	0.0400	0.0220	-0.4601	-0.4821	-0.3061	-0.276
).3221	-0.5481	0.1440	0.4081	-0.0720	-0.5541	-0.4681	-0.3761	-0.1540	-0.160
).0600	0.2721	0.1760	-0.2541	-0.0860	0.0420	0.0120	-0.5141	-0.4321	-0.322
).3861	-0.5901	-0.2981	-0.0580	-0.0960	-0.1680	0.1300	0.1880	-0.0560	-0.464
).2220	-0.0320	-0.0820	-0.5981	-0.3301	-0.0080	0.1260	0.0160	-0.1200	0.070
).3961									

Please refer to item 2 of the AIDE MEMOIR for the Tehri Dam meeting on October 9, 1997.

I beg to differ from the conclusion mentioned therein for the reasons I had given in the meeting which I elaborate here and also for additional reasons given below.

1. The strong ground motions recorded at Tehri for the 1991 Uttarkashi earthquake show a strong amplification in the T and the V components as shown in Figure 1 showing normalized response spectra(10% damping) of the three recorded components. The amplification as compared to the L component in the T component is by a factor of 3 and in the V component by a factor of 4. In the same figure I also show the Tehri Design Spectrum normalized to 1 g. It is seen that the response spectrum of T and the V components exceed very significantly the Tehri design spectrum in the period band of interest.

The report by DEQ in Figure 2 has compared only the L component which is not showing the amplification in question. Hence this comparison cannot provide information regarding the amplification recorded by the other components.

Further, the comparison of the mean + 1 sd response spectra from Uttarkashi earthquake, which was a magnitude 7 event only, for the purpose of general shape can not be used for drawing appropriate conclusions because larger magnitude earthquakes radiate larger amplitudes of longer period energy, and produce longer duration of strong motions. Therefore, the response spectra for larger earthquakes show a slower rate of decay with period.

In Figure 2 I show normalized response spectra for a number of ground motions for the 1991 Uttarkashi earthquake. The Tehri site is showing amplification in the transverse and the vertical components in the period range of interest while all the other sites do not. We therefore conclude that it is not an effect related to the source or the transmission path, and therefore is specific to the local conditions at the Tehri site. The strong anisotropy in the response is arising due to the topography at the site. The T component is approximately normal to the axis of mountains and valley with a wavelength of about 4-8km , which is the reason it is showing amplification in the wavelength range of about 4-8 km. Since the L component is approximately in the direction of the axis of the mountains and valleys it does not show a similar amplification.

2. The empirical methods for deriving the response spectra such as used by the DEQ provide the same for an average site. When a site has special amplification characteristics as observed at the Tehri site the same ought to be incorporated in a suitable manner.

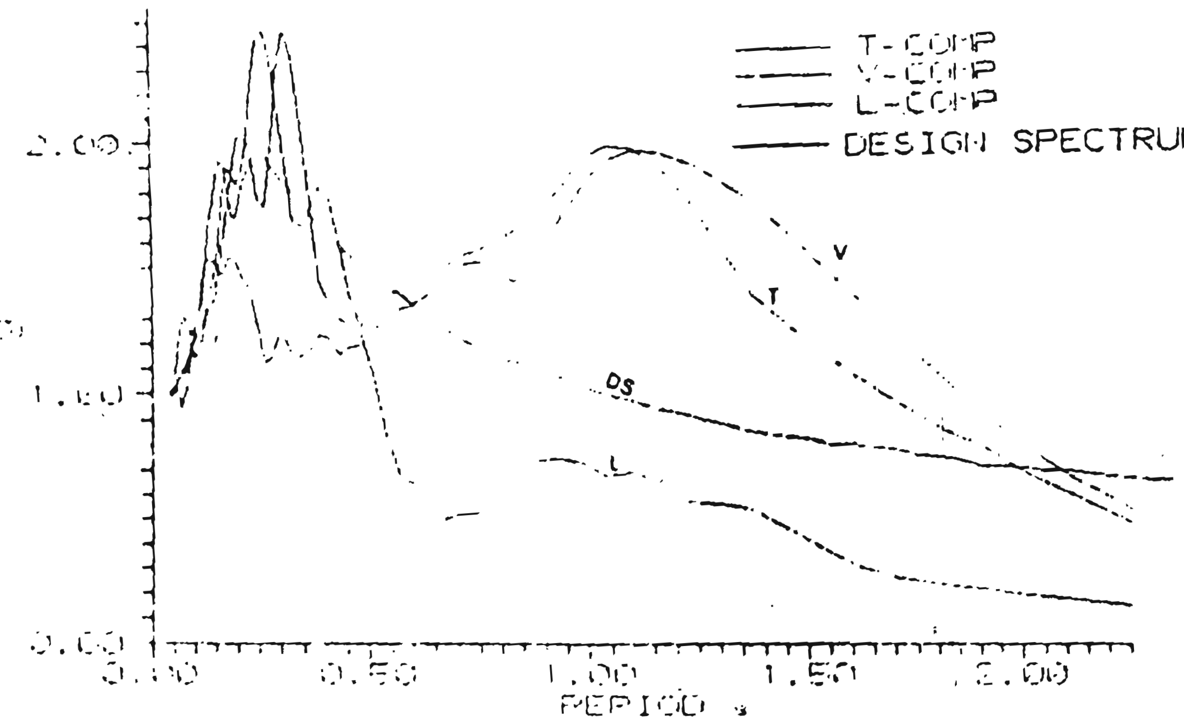
The amplification effect under consideration may be understood in terms of a filter acting on the input ground motions(corresponding to the estimated response spectrum) and amplifying the same in a certain frequency band. Thus the response spectra corresponding to this filtered and amplified ground motion will also show amplification in the same frequency band over and above the response spectra derived for average sites on the basis of empirical procedures.

In the report under reference by the DEQ, firstly a comparison has been made with only the L component which is not showing the strong amplification observed in the T and the V components(Figure 1 of the DEQ report). Further, the comparison made in Figure 5 of the DEQ report is not appropriate to bring out the effect of amplification and draw conclusions, firstly as mean response spectrum at Tehri is used, and secondly, a direct comparison as is made between the response spectra for a magnitude 7 earthquake having a mean pga(anchoring) of 0.066 g at a distance of 54km with the other spectrum having an anchoring pga of 0.25g.

In view of the above arguments, therefore, I request further reconsideration of this important issue.

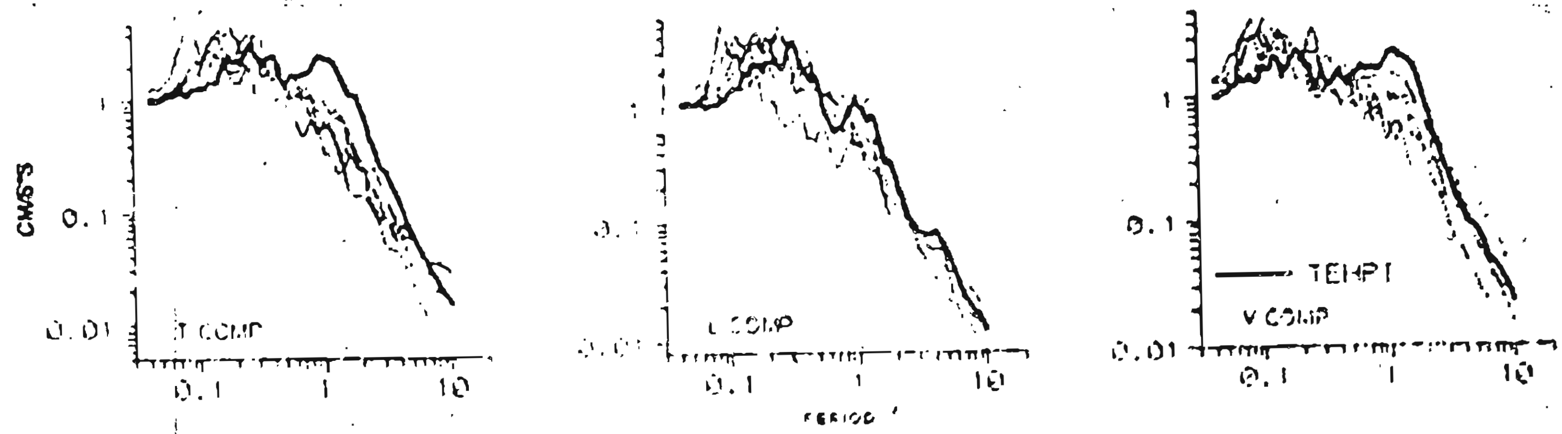
K.N.Khattri

RESPONSE SPECTRA - ANCHORED AT 1g - SITE : TEHRI
UTTARKASHI EARTHQUAKE 1991
DAMPING 10%



RESPONSE SPECTRUM - DAMPING 5%

(Other stations used are Uttarkashi, Barkot, Ghansiali, Srinagar and Koteshwar)



ANNEXURE-10

EARTHQUAKE ENGINEERING STUDIES EQ 98-02

MULTI LIFT NONLINEAR STATIC AND EARTHQUAKE RESPONSE ANALYSES OF 2D SECTION B-11 OF TEHRI ROCKFILL DAM

January, 1998

for official use only

DEPARTMENT OF EARTHQUAKE ENGINEERING
UNIVERSITY OF ROORKEE
ROORKEE, 247 667

Preface

The Expert Group on Safety Aspects of Tehri Dam, constituted by Government of India in their meeting on November 29, 1997 suggested to carry out the repeat seismic safety analysis of a section of dam which has the maximum depth of the core of the Tehri dam under strong motion earthquake as recommended in DEQ report EQ.83-04. The same was entrusted to Department of Earthquake Engineering, University of Roorkee. The study is a further extension of the earlier study reported in report EQ 97-09 entitled 2D Multilift Nonlinear Static and Earthquake Response Analysis of Tehri Rockfill Dam.

The above study has been carried out by Dr. D K Paul, Professor, Department of Earthquake Engineering. The help provided by Mr. Madhukar Agrawal, Sr.Engineer, THDC in providing, preparing and checking the computer input data at various stages of analysis is gratefully acknowledged.

January, 1998

(S. Basu)
Professor and Head

CONTENTS

INTRODUCTION

This study is a further extension of the earlier work reported in Department of Earthquake Engineering (DEQ) report EQ 97-09 wherein the 2D plane strain nonlinear elasto-plastic earthquake response analysis of the Tehri dam for a postulated maximum credible earthquake (MCE) has been carried out at Section B-15 to asses the stability of the dam. For this analysis, earthquake motion has been taken to correspond 10% damping response spectra as recommended in DEQ report EQ 83 - 04 with a peak ground acceleration (PGA) pegged to 0.5g. In the last meeting of Group of Expert Committee on 29 November 1997 at New Delhi, it was agreed upon to carry out the repeat analysis for a section which has a maximum core height.

The report therefore describes the theoretical studies carried out to assess the seismic stability of the section B-11 of the Tehri rockfill dam which is found to have the maximum core depth of 243.5 *m* when subjected to simulated earthquake as recommended in DEQ report EQ-83-04.

The static and the free vibration response analyses of the dam are investigated by finite element method. Effect of variation of material properties with confining pressure is accounted for in the analysis. The natural period of vibration are also studied for the first few modes of vibration.

The report describes the theoretical studies carried out to assess the seismic safety of the Section B-11.

OBJECTIVE OF THE STUDY

- A 2D plane strain nonlinear multi lift static finite element analysis for the gravity and hydrostatic water pressure to model the construction sequence and the reservoir filling. For the rockfill and clay core materials, the Mohr Coulomb elasto-plastic material model considering the variation of material properties with the confining pressure are to be taken into account.
- To study the free vibration characteristics of the dam, the material properties corresponding to the final stress state obtained from nonlinear multi-lift analysis will be used. The frequency of vibration and mode shapes are to be worked out.
- To carryout the 2D nonlinear elasto-plastic dynamic analysis of the dam for the postulated MCE condition and work out the maximum dynamic displacement and acceleration at the crest. The damping in the first two modes of vibration will be taken as 10%.

The modulus of elasticity for 2D elasto-plastic dynamic analysis will be modified in the square of the ratio of the fundamental time period of 3D and 2D free vibration analysis in order to match the fundamental time period of the 2D model of the dam with the 3D fundamental time period. The 3D fundamental time period specified by Expert Group is 1.25 sec.

The site dependent response spectra compatible acceleration time history of ground motion will be taken corresponding to DEQ report EQ-83-04. The spectra and time history of ground motion will be normalised to 0.5g PGA.

The settlement of some key locations will be worked out for the postulated earthquakes. The permanent crest settlement will be worked out at the end of the earthquake excitation.

SECTION OF THE DAM

The detail of the Tehri dam has been described in DEQ report EQ-97-09. Since the valley is curved at the dam site and therefore a full cross section for plane strain analysis is not available. The section corresponding to Section B-15 has been analysed earlier and now dam section having deepest core will be analysed.

The 3D computer simulation of the dam has been also made and section having deepest core has been located. Figure 1 shows the isometric view of dam section at the maximum core height Figure 2 shows the 2D dam section obtained from the section of 3D computer model. The data for the generation of 3D model was provided by THDC. Figure 3 shows the 2d dam section at B-11 with maximum core height provided by THDC with coordinates of important locations. It is seen from Figures 2 and 3 that both the figures are almost identical. The same section has been taken for the analysis.

LOADS ACTING ON THE DAM

Static Loads: The static loads are mainly due to self weight which is worked out by evaluating the equivalent nodal loads. The water pressure is taken as edge load acting on the unstream face of the core. In the full reservoir condition the water level is taken upto 830.0 m.

Input Earthquake Ground Motion: The Maximum Credible Earthquake (MCE) is taken as the input motion. MCE is the most severe earthquake that may occur once in the life time of the dam. Under its effect the dam may undergo distress in the form of cracks (which could be repaired) without undergoing failure. For linear elastic earthquake analysis, 10% damping response spectra as recommended in DEQ report EQ-83-4 has been taken with Peak Ground Acceleration (PGA) pegged to 0.5g.

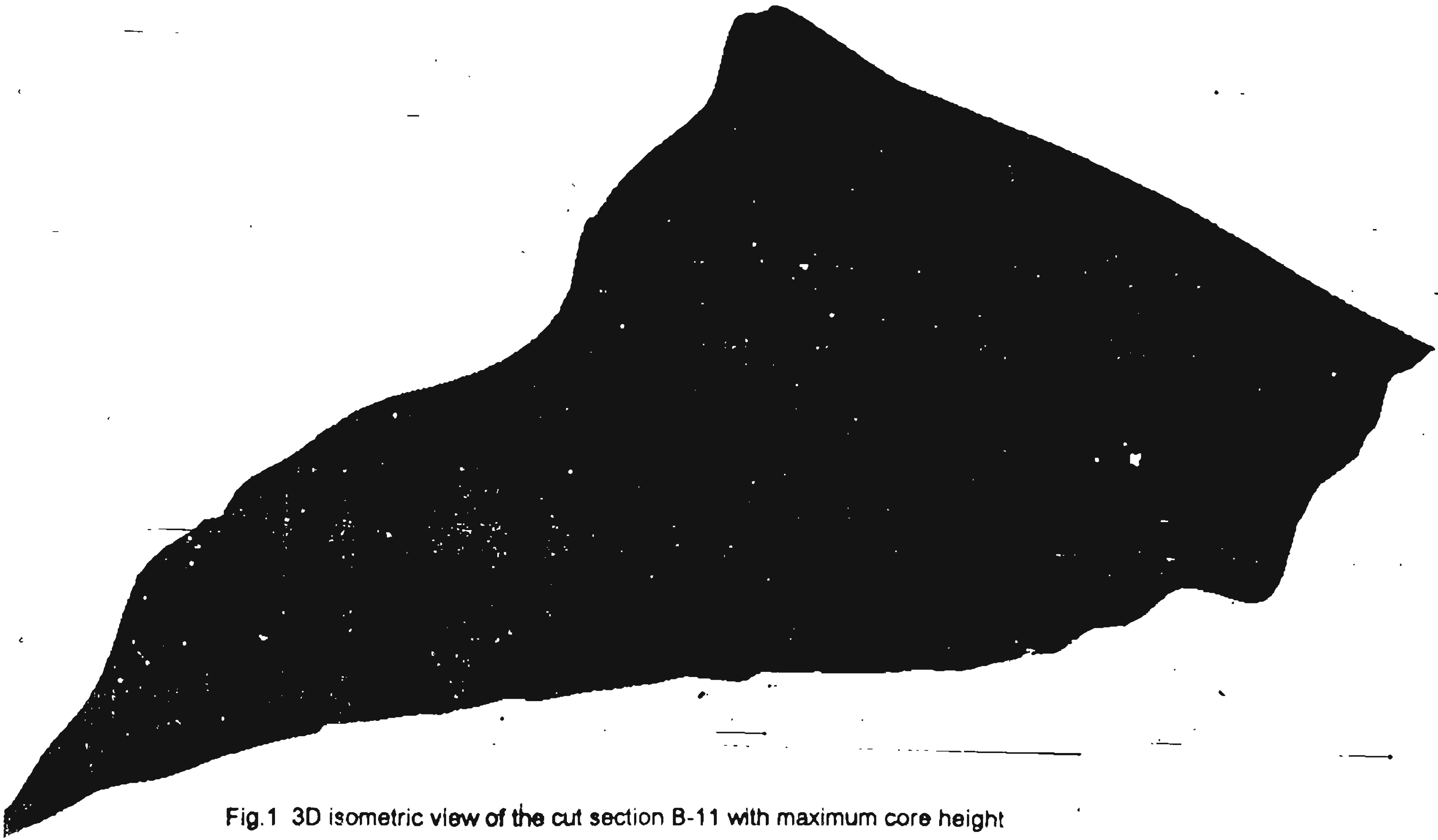


Fig.1 3D isometric view of the cut section B-11 with maximum core height

Fig.2 2D computer-generated section B-11 with maximum core height

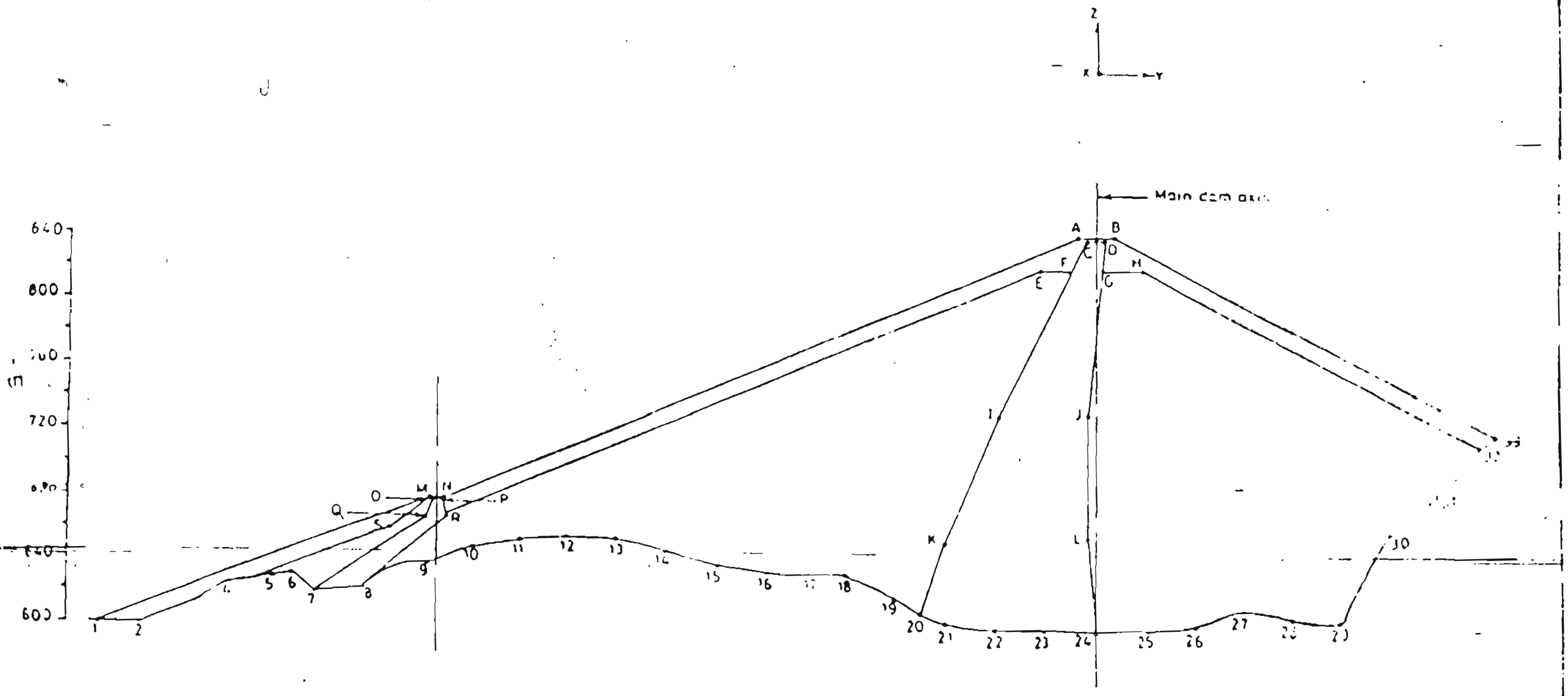


Fig.3: 2D dam section at B-11 with maximum core height provided by THDC

The motion at the base of the dam is taken as the input motion for this analysis. The response spectra compatible earthquake time history is taken as per Ref.1 and shown in Fig.4. The vertical ground motion is taken as 2/3 the strength and in phase with the motion in horizontal direction.

MATHEMATICAL MODEL AND DISCRETISATION OF THE SYSTEM

The geometry of the dam and zones identifying the different material properties is shown in Fig.3.

Finite Element Discretization: Plain strain idealization of the dam has been carried out. For the analysis eight noded isoparametric elements have been used. The discretization has been done to map the material boundaries. There are a total of 202 elements to map the entire dam section. The total number of nodes is 673. The nodes at the base of the dam are assumed to be fixed. The water pressure at full reservoir condition is taken as edge load on the u/s portion of the clay core. The discretization of the dam is shown in Fig.5(a). The element and node numbering are shown in Figs.5(b-c). Same finite element mesh is used for both single and multi lift analysis The Mohr-Coulomb yield criteria is used to model the nonlinear behaviour of soil.

The mesh is discretised in such a way that year wise construction layers are easily taken care in the analysis. The numbering of the elements is done horizontally to facilitate the computation for sequential construction.

SOIL PROPERTIES

Having determined shear modulus at a confining pressure and shear strain level from tests on rockfill, it can be determined at any other confining pressure and shear strain level. Consideration of this effect, the stiffness of dam increases with depth. To take into this variation in the dam analysis, a power law variation of shear modulus has been used as described in DEQ report EQ 97-09. This variation in material properties corresponds to a variation of very small shear wave velocity to 437.9 m/s at a depth of 250 m in shell material. An average value of shear wave velocity in shear works out to about 315.0 m/s. For core material, these values at a depth of 250m works out to 350.0 m/s with an average value of 250.0 m/s.

The material properties taken for the rockfill dam analysis are listed in Table 1

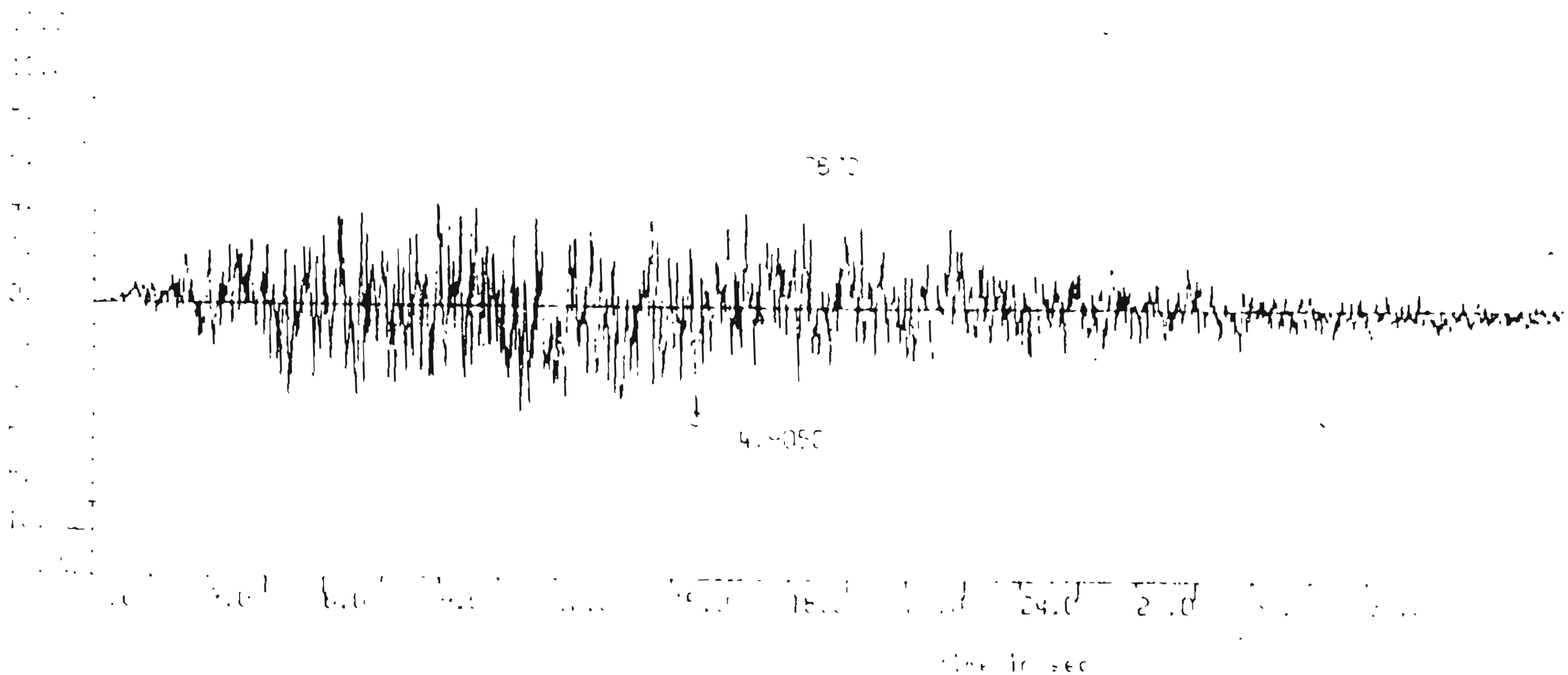


Fig.4 Postulated earthquake at Tehri dam site (PGA=0.5g or 4.905 m/s^2)

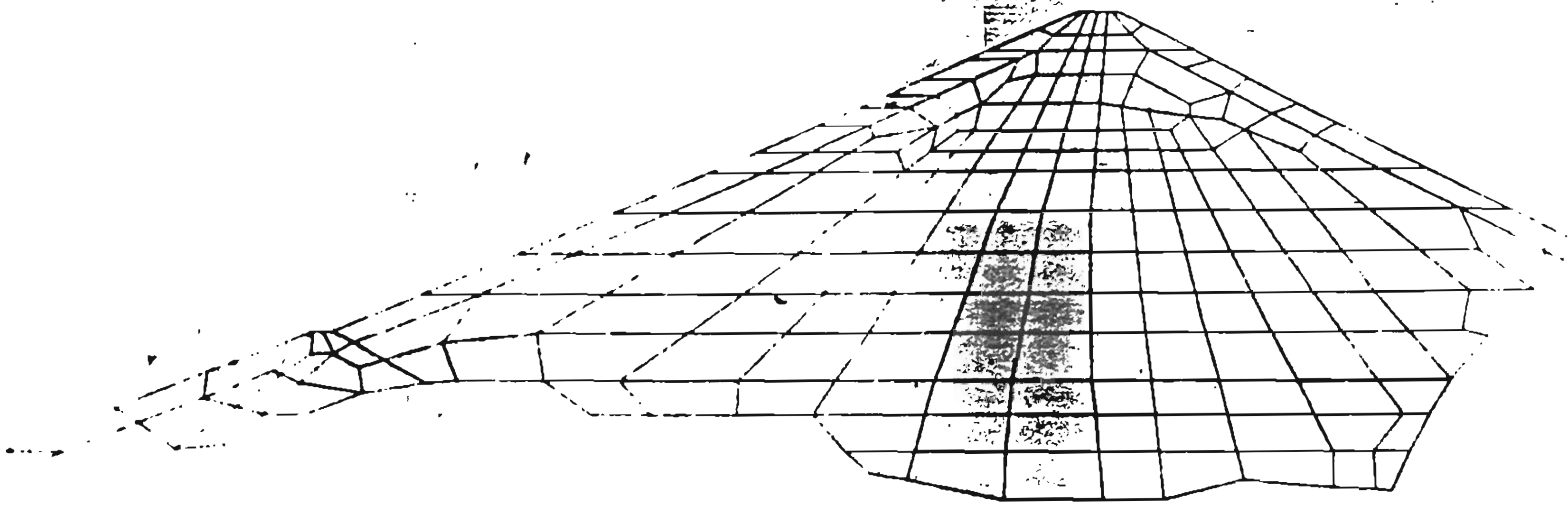


Fig.5(a) Finite element discretisation of the dam section

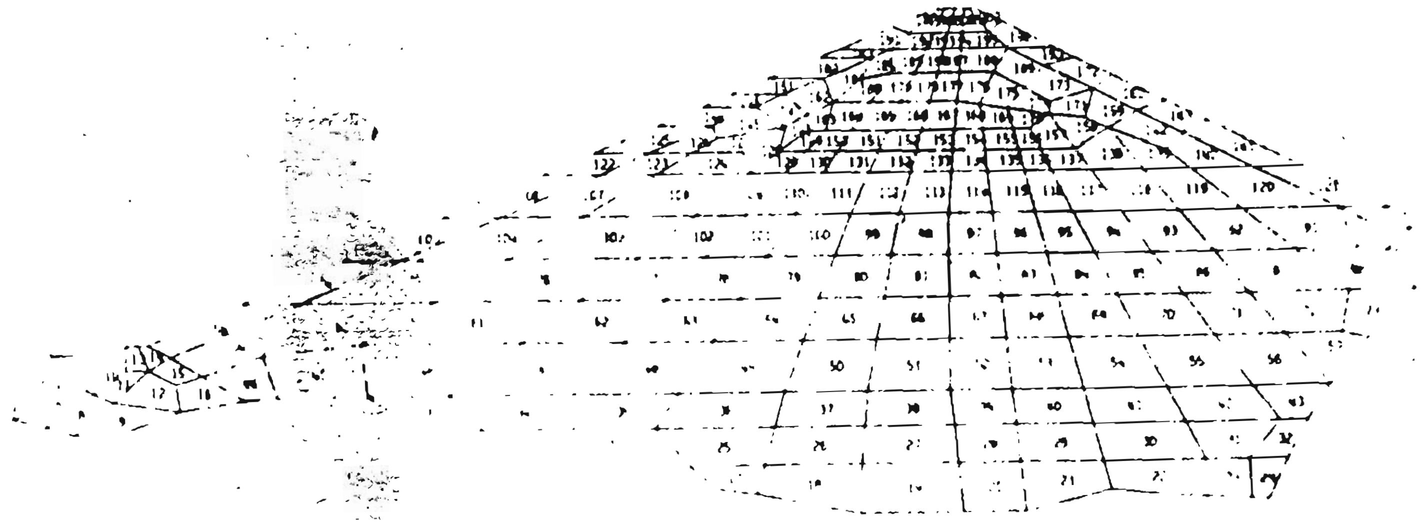


Fig.5(b) Finite element mesh showing element numbers only

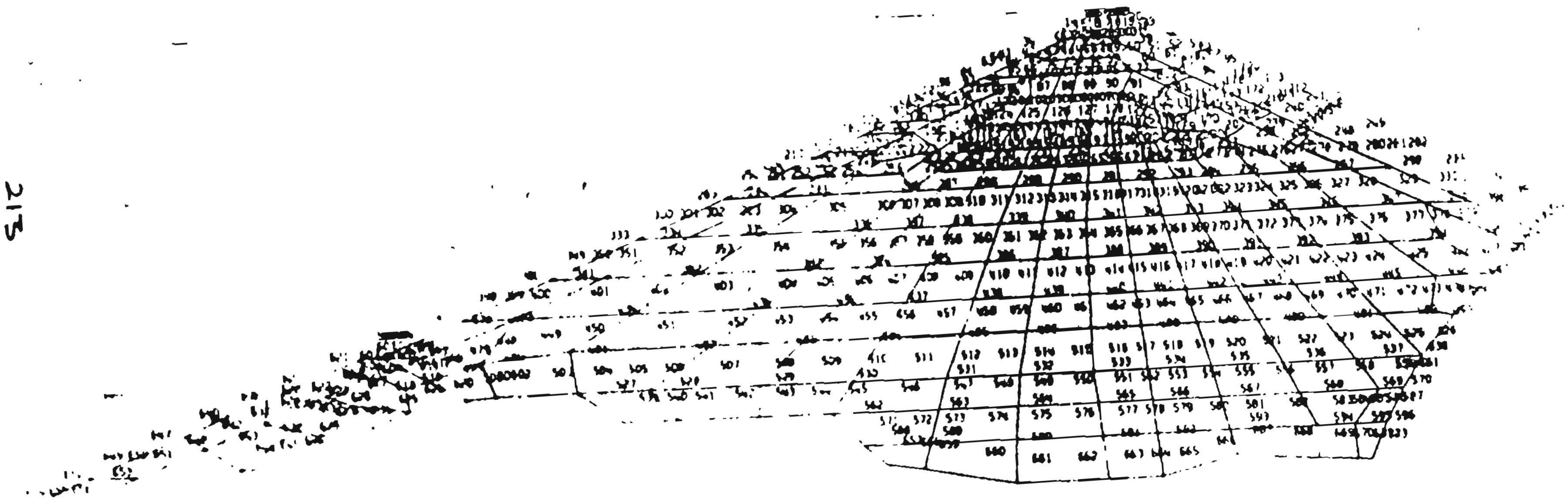


Fig.5(c) Finite element mesh showing node numbers only

Table-1 Material properties

sl. no	property	shell	rip-rap	core
1.	shear modulus, G (t/m^2)	6000 0	6000 0	3000.0
2	modulus of elasticity (t/m^2) at 10(t/m^2) confining pressure	0.162e+05	0.150e+05	5400
3	Poisson's ratio	0 35	0 25	0 30
4.	moist density (t/m^3)	2.45	2.00	2 00
5.	saturated density(t/m^3)	2 49	2 16	2 15
6	dry density (t/m^3)	2 36	1.80	1 85
7	cohesion, c (t/m^2)	7.00	0 50	5 00
8	effective angle of internal friction (degree)	42.0	42 0	28 0
9	power variation of G, m	0 5	0 5	0 3

The dynamic modulus of elasticity has been taken such that the fundamental time period of vibration of dam is 1 25 sec i e the static modulus of elasticity is multiplied by a factor $(2.2427/1.25)^2 = 3.219$, where 2 2427 sec is the time period of Section B-11 obtained with the static material properties

In static analysis, the submerged unit weight has been taken for the u/s shell element, except the top elements above the phreatic line of u/s shell for which dry density has been taken Saturated unit weight has been taken for the core Dry density has been taken for the d/s shell For dynamic analysis saturated unit weight has been taken for the u/s shell elements

ELASTO-PLASTIC ANALYSIS

In the analysis, the stress-strain relation which exhibit an elasto-plastic behaviour of soil is considered where the elasto-plastic behaviour follow the Mohr Coulomb yield criterion The detail of analysis is described in Ref 3

The response evaluation provides time histories of stress, displacement and acceleration at desired locations/element during the earthquake

ANALYSIS OF THE DAM

Static and earthquake response analysis of Section B-11 is carried out to study the stability of dam. Finite element method is an important tool to determine the stresses and deformations of a dam during the construction phase and normal operating conditions

Static analysis: Analysis of the high rockfill dam is carried out for static loads due to self weight, water pressure and uplift. Static deformations of dam are of interest because excessive deformations can lead to loss of free board and danger of over topping. Excessive spreading may lead to longitudinal cracking and adversely affect stability. Differential settlement along the axis of the dam may lead to transverse cracking which could allow passage of water. Differential settlement between the core and shell can lead to stress reduction in the core and may result in hydraulic fracture

Determination of initial static stresses: In static analysis it is convenient to use incremental procedure The main reasons are

- They permit simulation of actual sequence of events involved in construction and loading of the dam. The geometry of the finite element mesh can be changed during each increment of the analysis to simulate addition of fill to the embankment, and water loads can be added in stages, simulating the rise of the water level in the reservoir

- They permit simulation of nonlinear and stress-dependent behaviour of the rock fill. The values of modulus and Poison's ratio assigned to each element can be adjusted during each increment of the analysis in accordance with the values of stress calculated in the analysis

Analysis is made to determine the internal deformation of the core and the shell, obtaining stress distribution and load transfer within the dam section, location of zones of potential cracking resulting from tensile stresses and investigating the likelihood of hydraulic fracturing

Sequence of construction Table 2 indicate the sequence of construction as detailed out by the project authorities.

Table -2 Sequence of construction of Tehri dam

Year of construction	Dam level (m)	Water level in reservoir (m)
1	661.0 (coffer dam) 638.0 (main dam)	656.0
2	700.0	656.0
3	760.0	706.0
4	820.0	742.0
5	839.5	830.0

Figures 6(a-h) show the eight stages of construction and reservoir fillings The dam is proposed to be constructed in five years The figures also show the loading at various stages In the case of water impounded in the reservoir, the weight of the rockfill under water is taken as submerged while the water pressure is assumed to act on the sloping face of the core as an external load

Frequency analysis: The frequency analysis has also been carried out to study the free vibration characteristics of the dam based on the final stress distribution obtained from nonlinear static analysis

Earthquake response analysis It is evaluated for the postulated seismic environment It involves the determination of the initial stress in the embankment before the earthquake and estimation of acceleration time history of the postulated earthquake at the base rock Evaluation of the rockfill dam response to the base rock excitation is then carried out which requires appropriate soil model and soil properties Response of the dam include the evaluation of stresses, deformations and stability of cross section of the rockfill dam

RESULTS AND DISCUSSIONS

Static stresses

Stresses due to both single and multiple lift nonlinear static analysis by finite element method has been carried out

Multi lift Nonlinear Static Analysis. For multi lift nonlinear static analysis the construction schedule of raising of the dam and the schedule of reservoir filling was taken into account In the first lift, only a portion of d/s and coffer dam are laid and static analysis for gravity load is carried out. Similarly, other layers are also analysed The initial stresses of the previous layer were taken into account.

In the case of sequential construction however each layer is considered separately. The analysis is first carried out for the first layer using trail values of E and

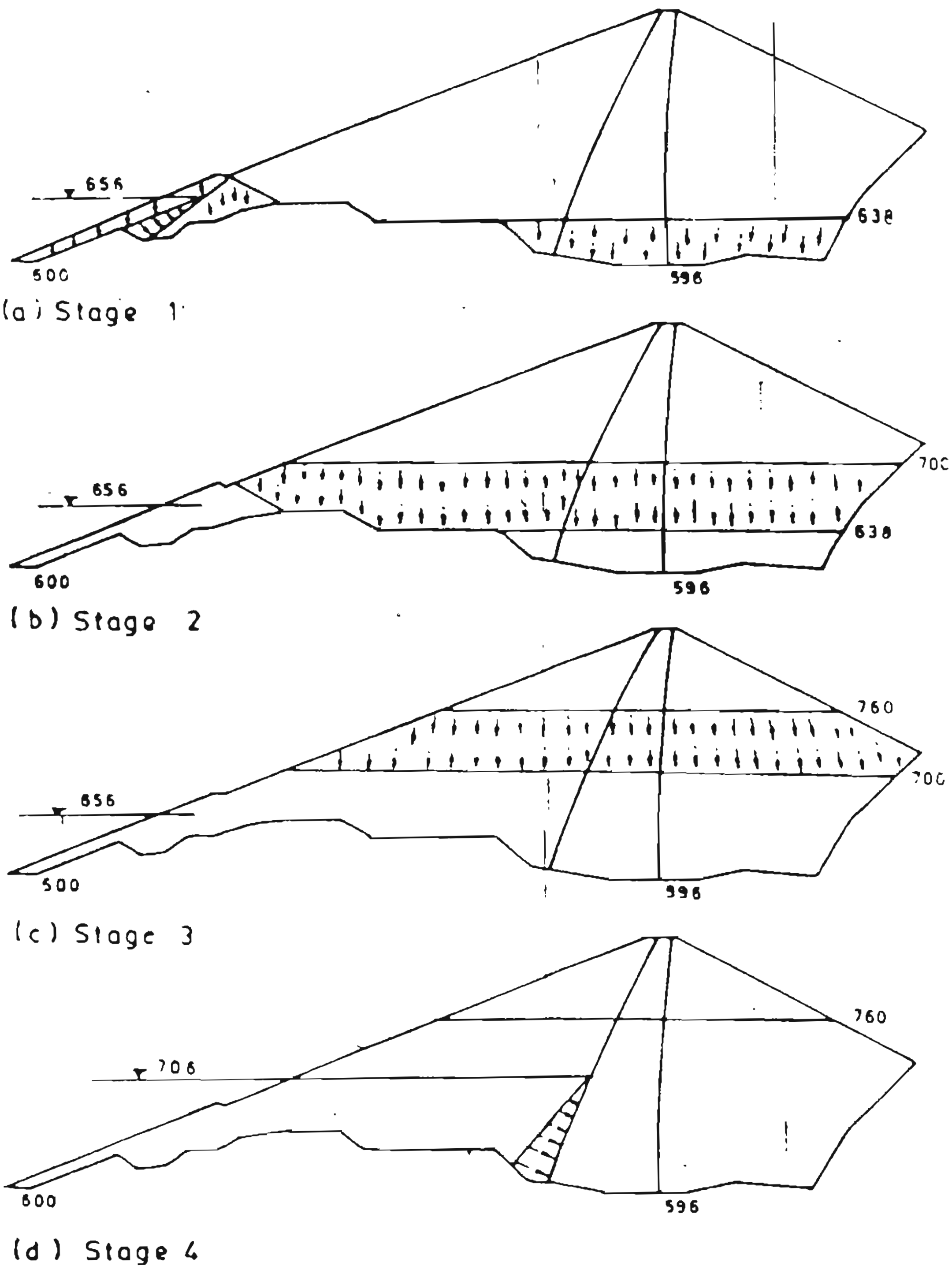
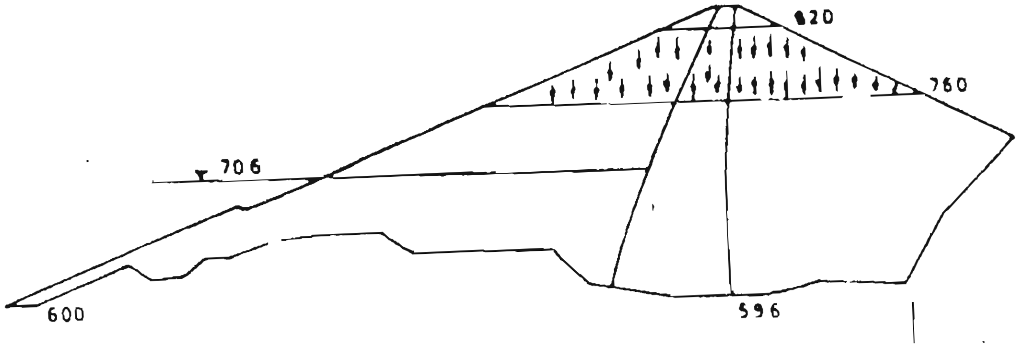
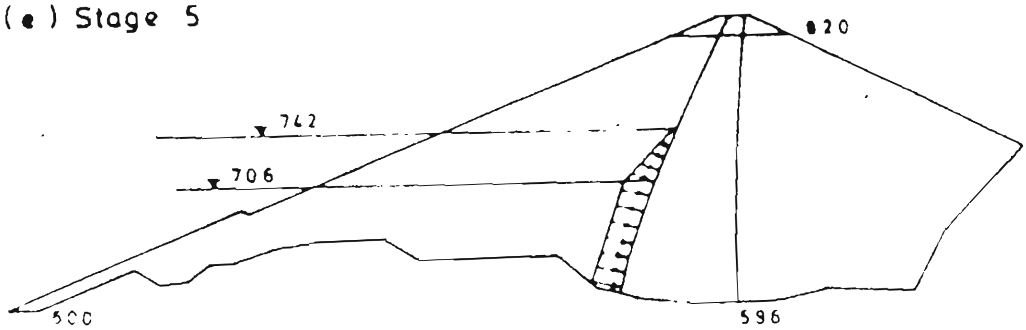


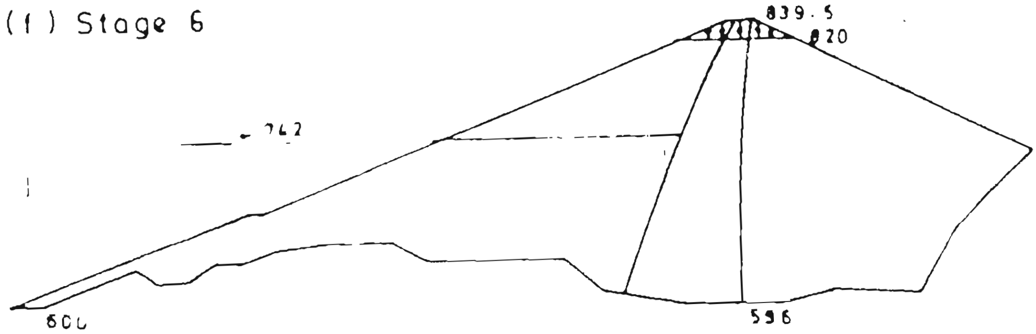
Fig 6(a) Sequence of construction and reservoir loads (cont)



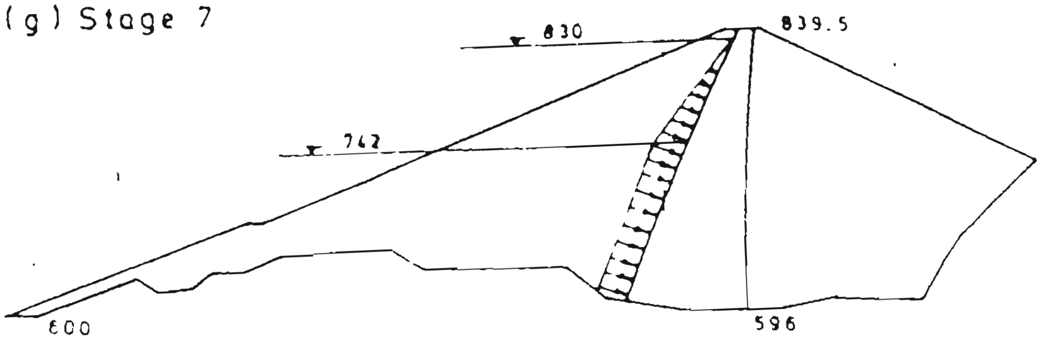
(e) Stage 5



(f) Stage 6



(g) Stage 7



(h) Stage 8

Fig 6(b) Sequence of construction and reservoir loads for each element The evaluated stresses are used to calculate the confining pressure which is used to calculate the corrected value of E The procedure is iterative and iterations are continued till convergence is met

Eight stages are considered for the nonlinear multi lift analysis The normal vertical stresses, shear stresses, major principal stresses, minor principal stresses are determined for each layers and the stress contours are plotted in Figs. 7 to 14.

The contours of plastic strains are also plotted at each stage of construction and are shown in Figs 15 to 22 It is seen that the plastic strains are confined mostly near the surface of u/s and d/s slopes

Figures 23 and 24 show the vertical and horizontal deformations obtained from multi lift analysis. The maximum vertical and horizontal displacements are found to be 2 0 m and 0 3m near the center of the dam

Figure 25 shows the direction and magnitude of principal stress at the end of construction and reservoir filling

Free Vibration Characteristics Of The Dam

For computation of eigen values and the mode shapes the inverse iteration technique is used for the solution For the eigen value analysis, the stiffness of the dam section is evaluated considering the variation of the Young's modulus with the depth of the dam The variation of the Young's modulus is computed from the power variation Since the values of the Young's modulu are known at a confining pressure of 10 t/m^2, Young's modulus of elasticity can be computed at any other confining pressure. The power (m) is taken as 0 5 for the shell material whereas for clay it is taken as 0.3 Nonlinear variation of the Young's modulus E is computed from the initial stresses obtained by nonlinear multi lift static analysis at the end of construction The time periods of the dam for the first eight modes are shown in Table-3 for the two cases, with and without modification in material properties

Table-3 Frequencies and Time Periods of the dam

mode no	frequenc, in (Hz)	with modified properties time period T (sec)	without modification in material time period T(sec)
1	0 8000	1 2500	2 2427
2	1 1920	0.8389	1 5640
3	1 2985	0 7701	1 3744
4	1 4850	0.6734	1 3042
5	1 5783	0 6336	1 0576
6	1 7504	0 5713	1 0203
7	1.7995	0 5557	0 9086
8	1 8822	0 5313	0 8273

Figures 26 and 27 show the first eight mode shape of vibrations of the dam As can be seen from the figure that the first mode of vibration of the dam has a time period of 1 25 sec which is predominantly a lateral translation mode

Earthquake response

Figure 28 shows the time history of horizontal and vertical accelerations at the crest obtained from non-linear analysis and their peak values are 11.14 m/s^2 (more than 1.0g) and 6 92 m/s^2 respectively. Figure 29 show the time history of horizontal and vertical displacements at the crest and their peak values are 40.25 cm and 25.87 cm respectively Figure 30 show the time history of principal stresses at the base of the core

Figures 31-33 show the plastic strains, volumetric strains and major principal strains developed in the dam body at the end of the earthquake It is seen that the plastic strain are confined mainly to u/s and d/s surfaces of the dam. The maximum plastic strain is found to be 0 08

SUMMARY

The static and the free vibration response of Section B-11 of the rockfill dam is carried out taking into account the effect of material property variation with confining pressure, non linearity, the schedule of raising the dam and the schedule of reservoir filling

Static Response

Multi lift Nonlinear Analysis The multi lift nonlinear analysis shows no tension region in the shell which is more realistic since the loading applied is primarily gravity loading

The vertical and horizontal deformations obtained from multi lift analysis are found to be 2 0 m and 0 3m near the centre of the dam.

Free Vibration Characteristics

The free vibration analysis is carried out taking into account the variation of Young's modulus with depth The variation of the Young's modulus is computed from the power distribution. Nonlinear variation of the Young's modulus was computed from the initial stresses obtained by nonlinear multi lift analysis

The dynamic material properties are modified so as to achieve fundamental time period of vibration equal to 1 25 sec. The fundamental vibration mode shape is a lateral translation mode and the second mode shape is primarily a vertical translation mode. The translations are much more pronounced near the crest of the dam.

Earthquake Response

The nonlinear dynamic analysis has been carried out for the postulated ground motion at Tehri dam site. The peak values of horizontal and vertical accelerations at the dam crest are found to be 11 14 m/s^2 (more than 1.0g) and 6.92 m/s^2 respectively. The peak values of horizontal and vertical displacements at the dam crest are found to be 40.25 cm and 25.87 cm respectively. Table 4 gives the comparison of earthquake response for the two sections of the dam.

Table -4 Comparison of earthquake response for the two Sections B-11 and B-15

sl. no	parameter	Section B-11	Section B-15
1.	horizontal acceleration at dam crest (m/s2)	11.14	9 59
2	vertical acceleration at dam crest (m/s2)	6.90	4 26
3	horizontal displacement at dam crest (cm)	40.25	38.69
4	vertical displacement at dam crest (cm)	25.87	14.78

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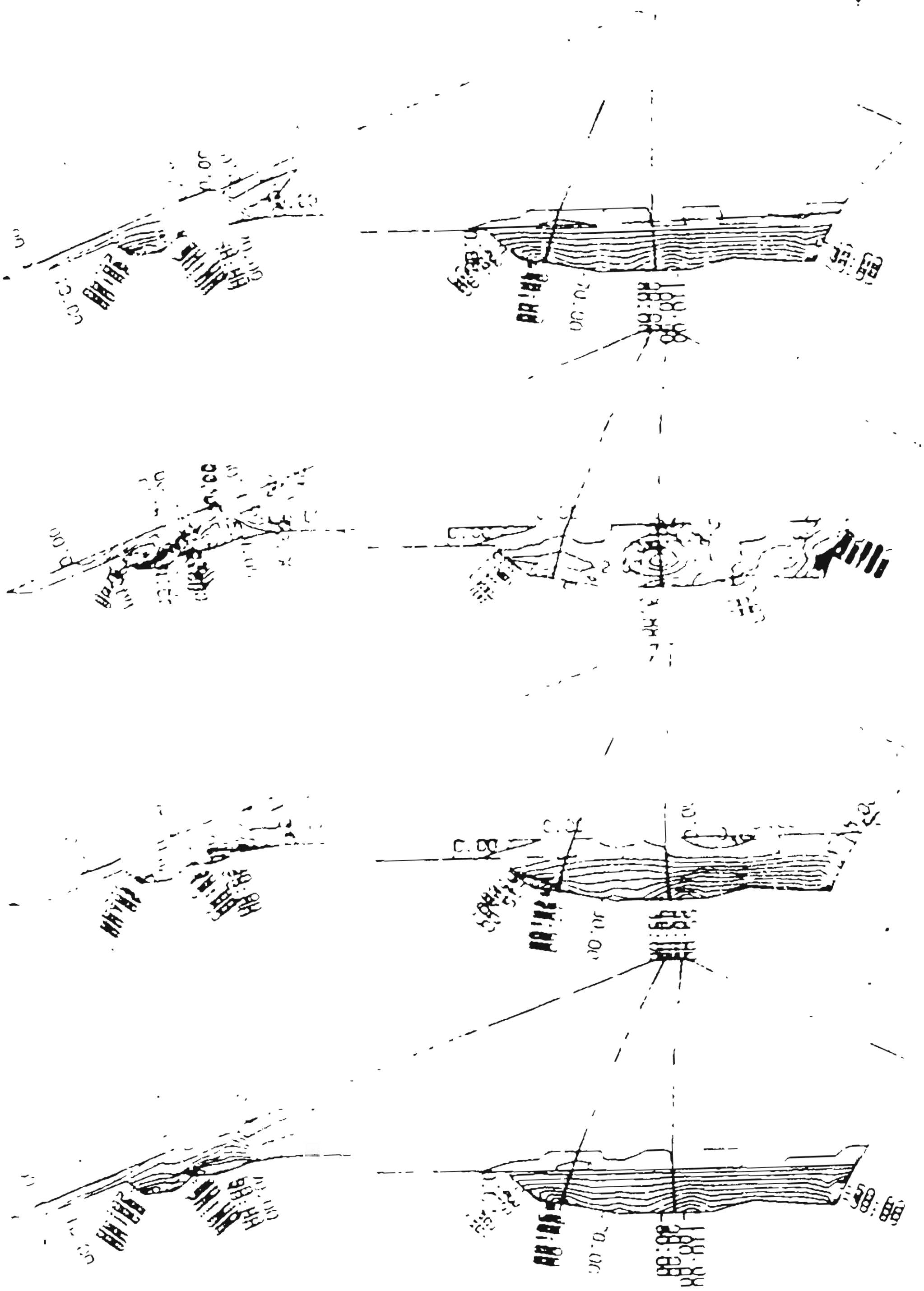


Fig.7 Nonlinear static stress - first lift analysis (stage 1)

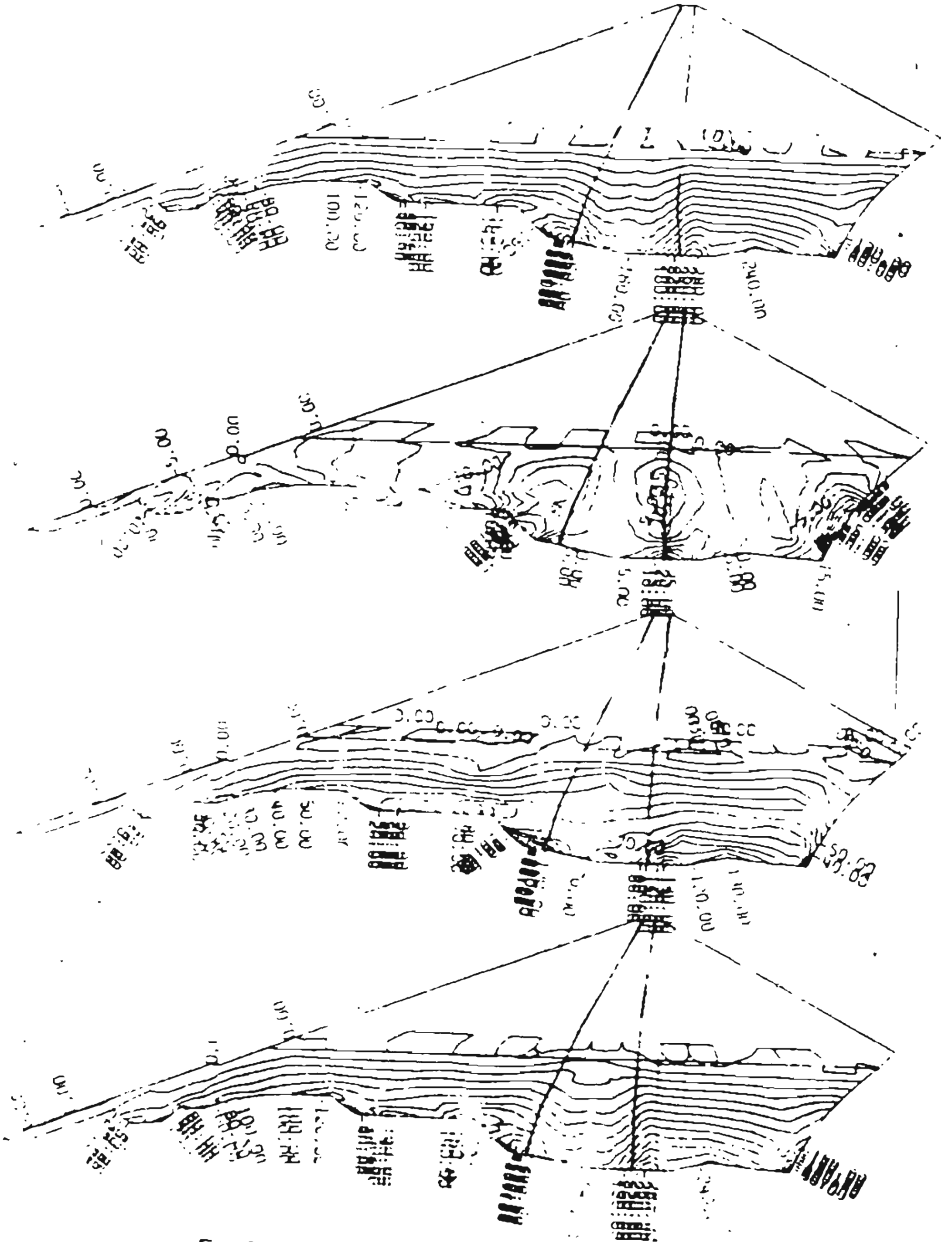


Fig 8 Nonlinear static stress - second lift analysis (stage 2)

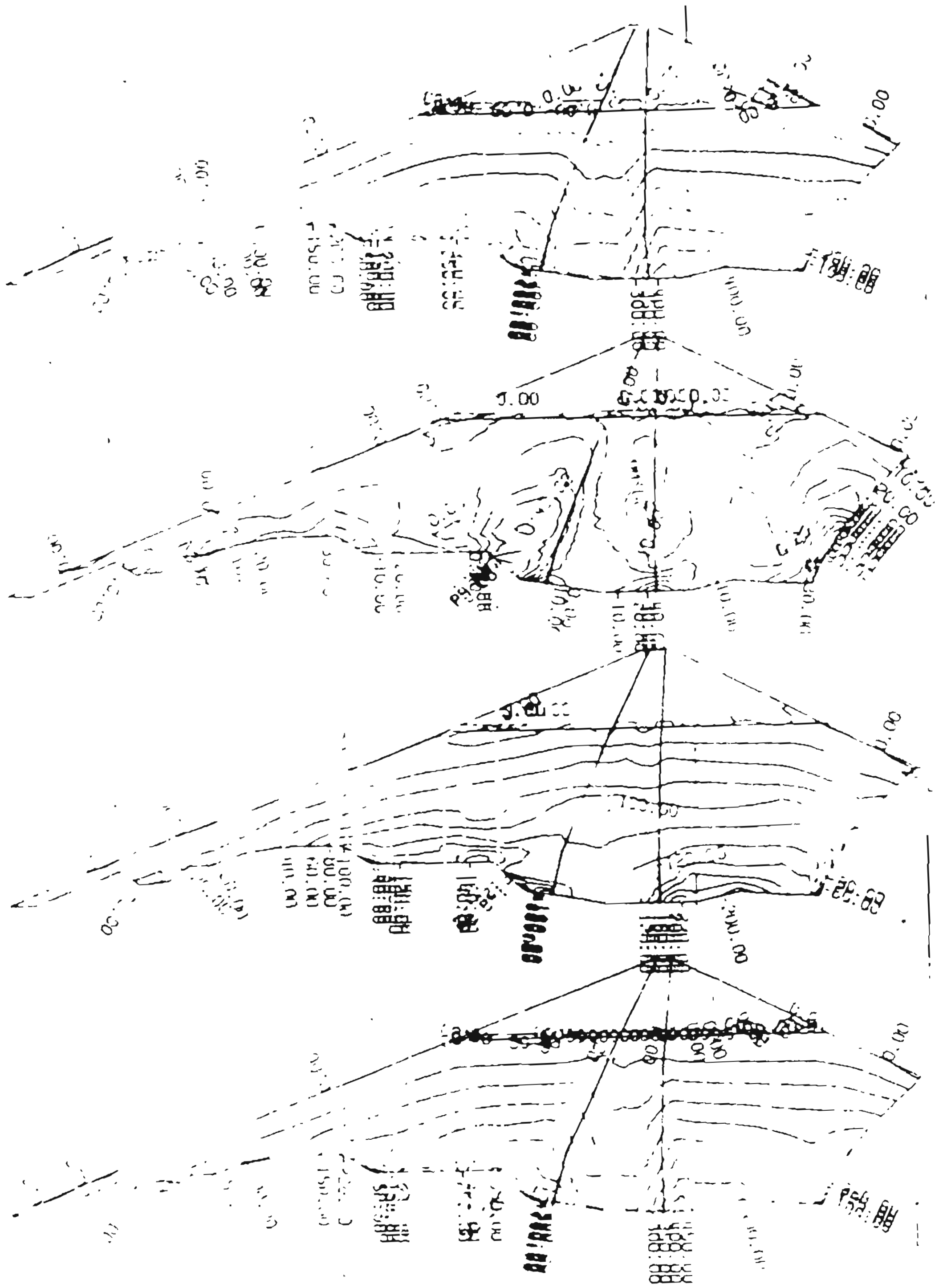


Fig.9 Nonlinear static stress - third lift analysis (stage 3)

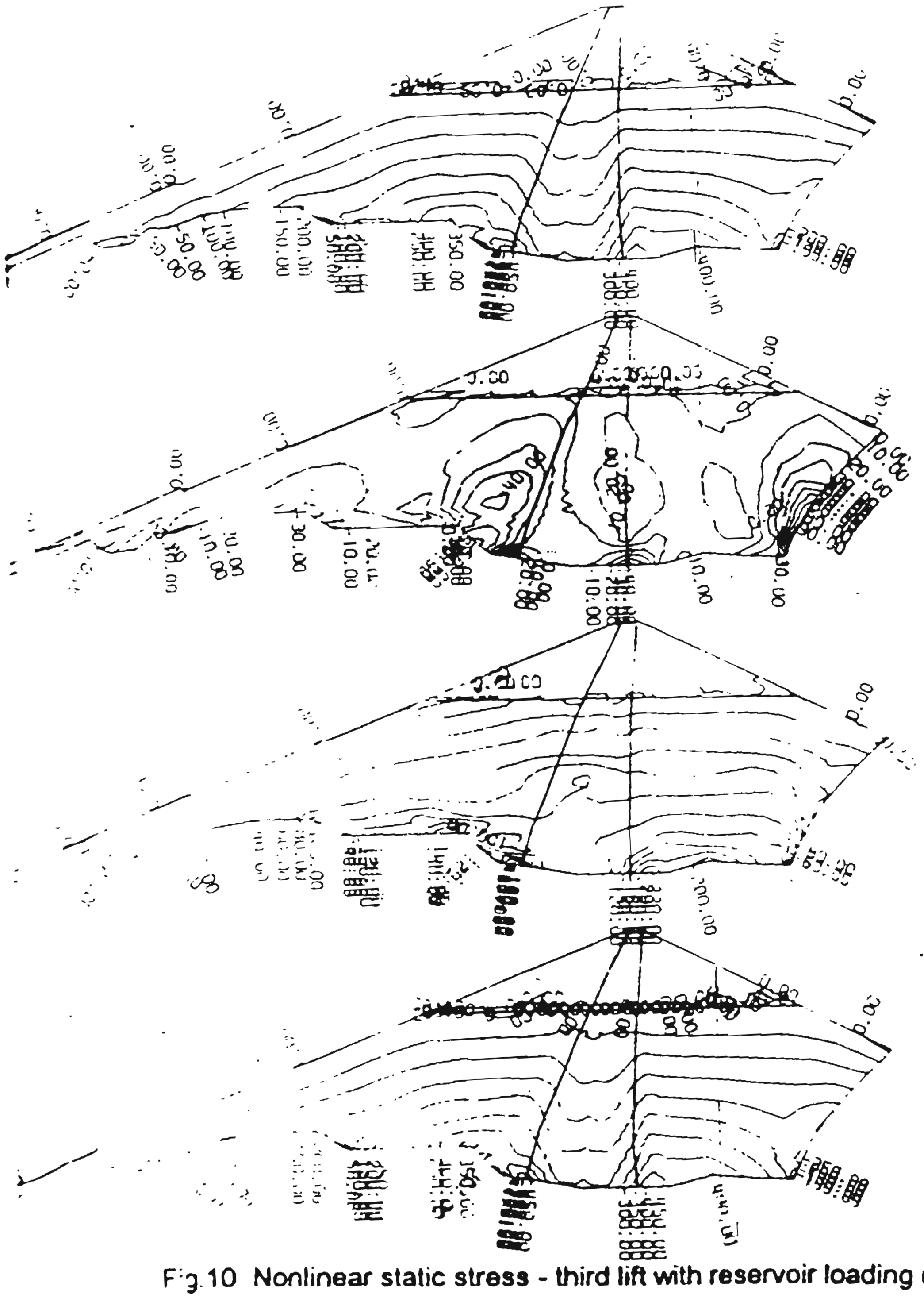


Fig.10 Nonlinear static stress - third lift with reservoir loading upto 706 (stage 4)

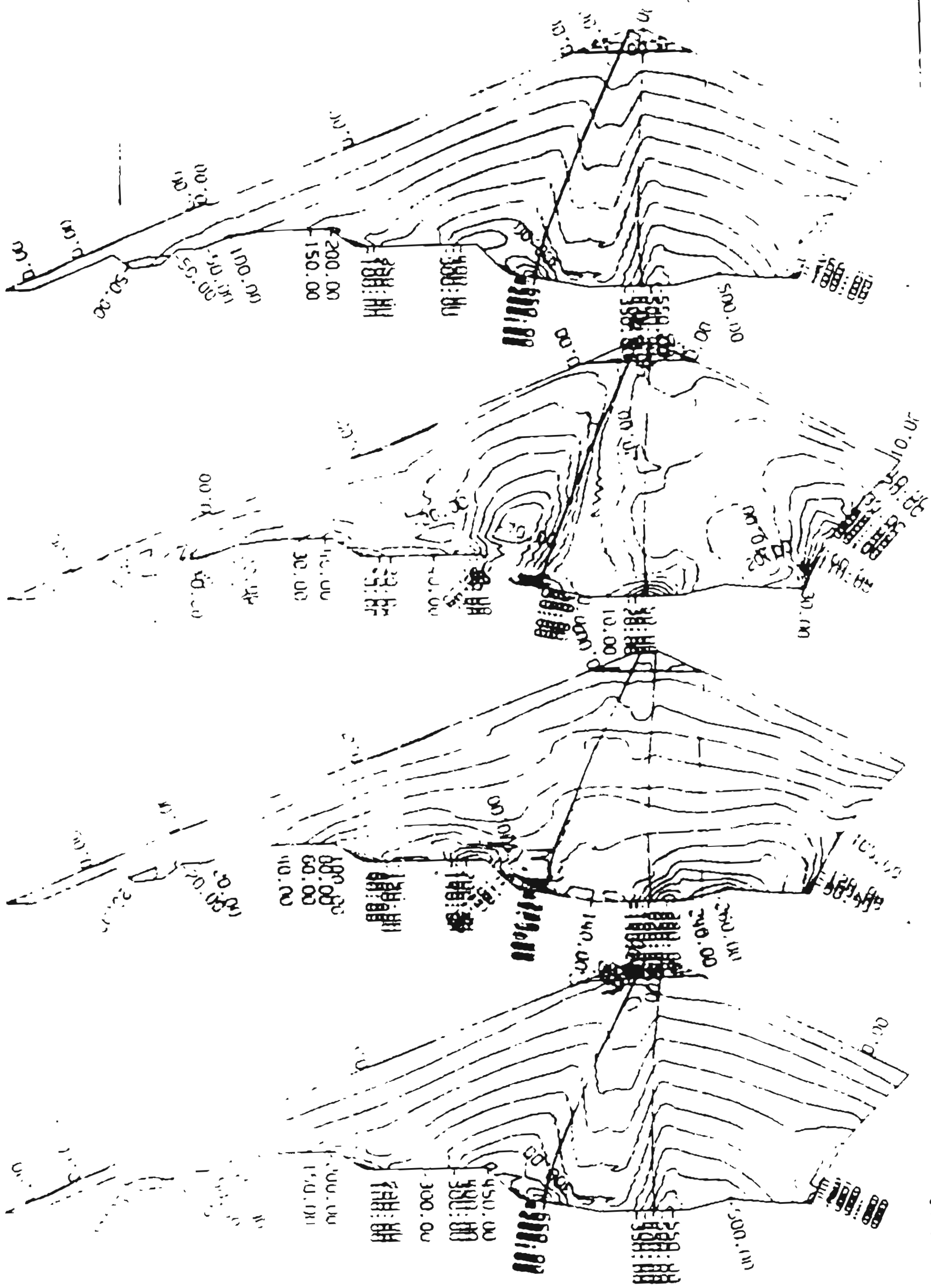


Fig.11 Nonlinear static stress -fourth lift analysis (stage 5)

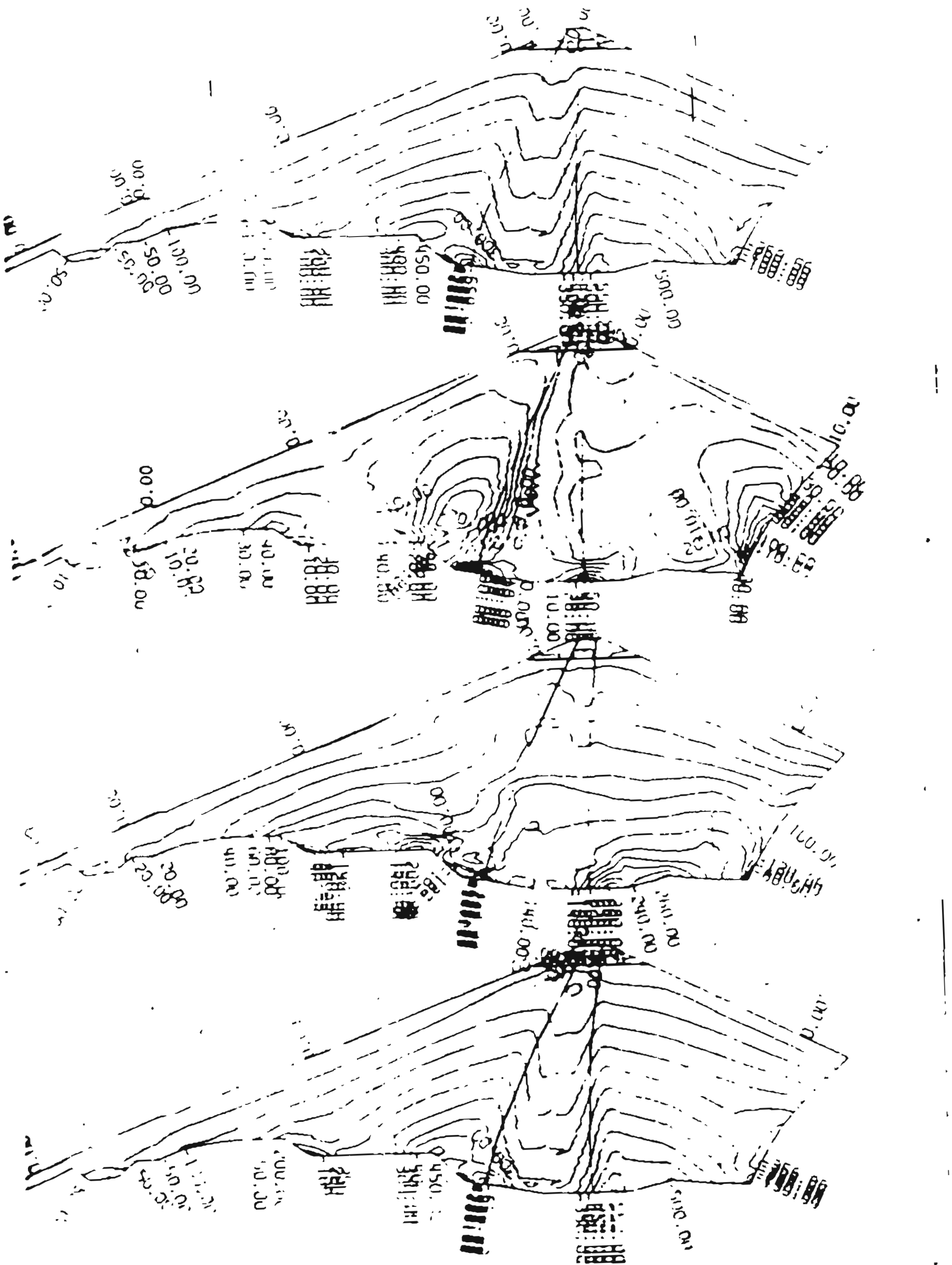


Fig.12 Nonlinear static stress - fourth lift with reservoir loading upto 742 (stage 6)

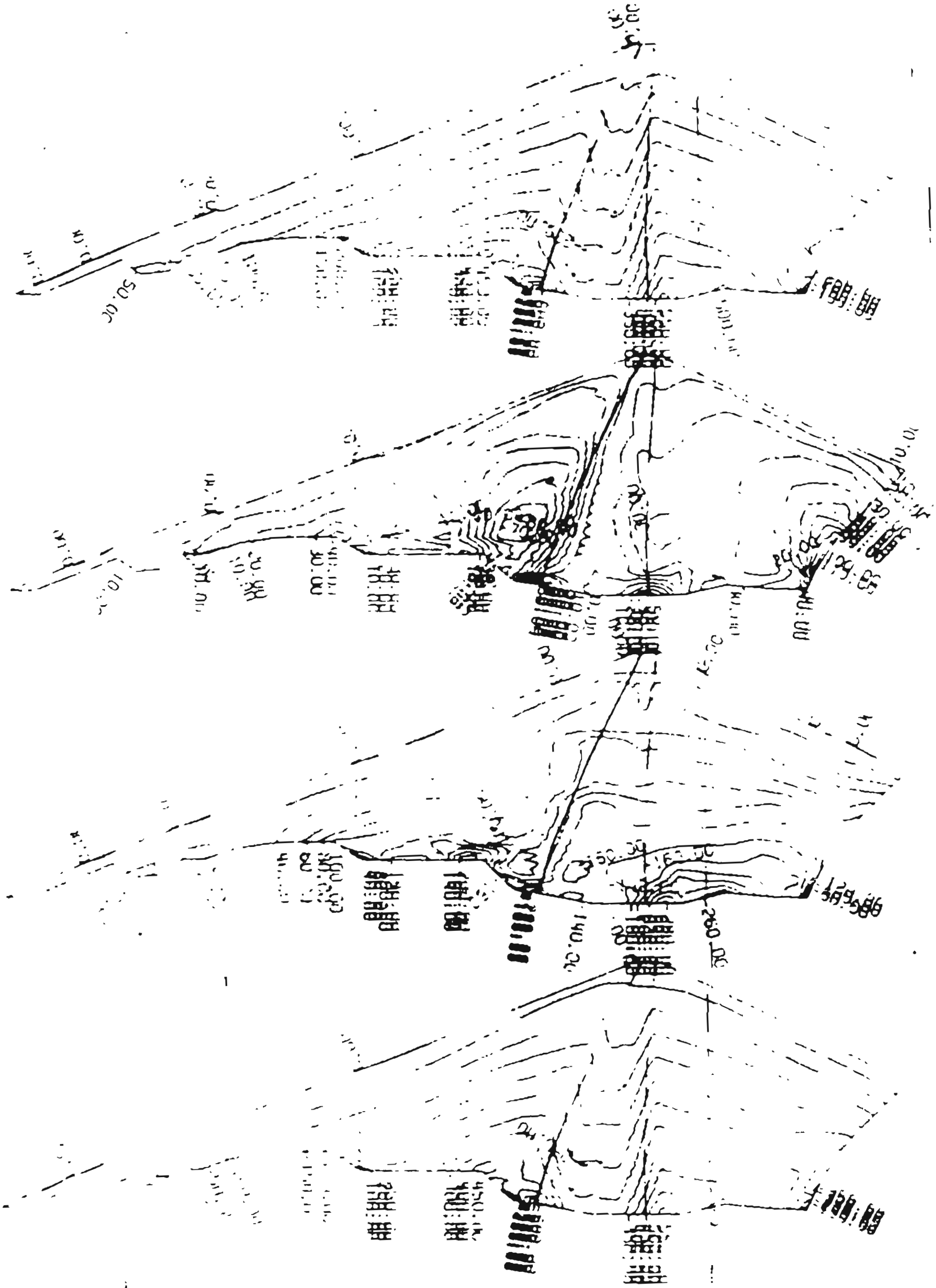


Fig.13 Nonlinear static stress - fifth lift analysis (stage 7)

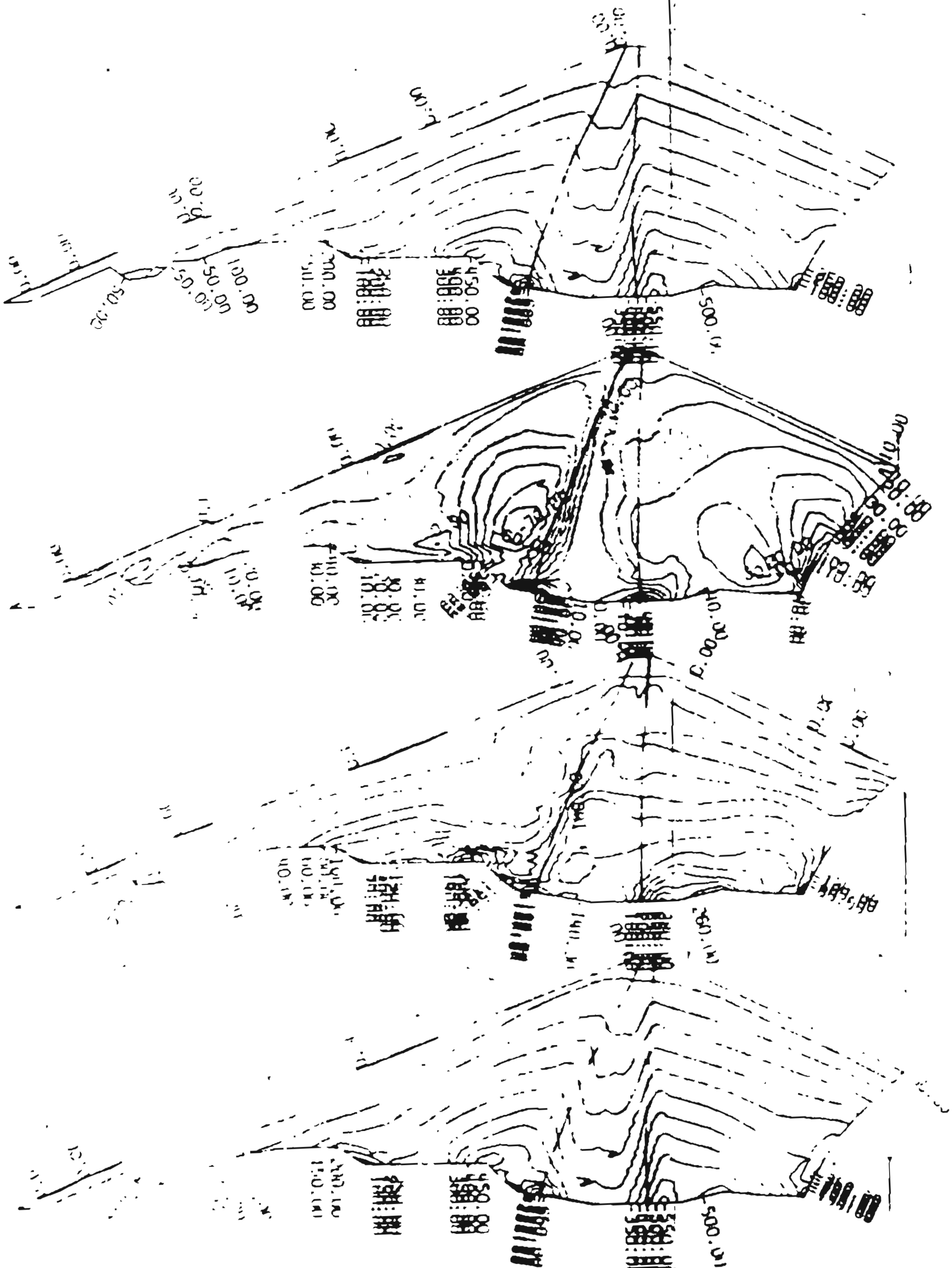


Fig.14 Nonlinear static stress - fifth lift with reservoir loading upto 830 (stage 8)

Fig.15 Contours for plastic strain - stage 1

Fig.16 Contours for plastic strain - stage 2

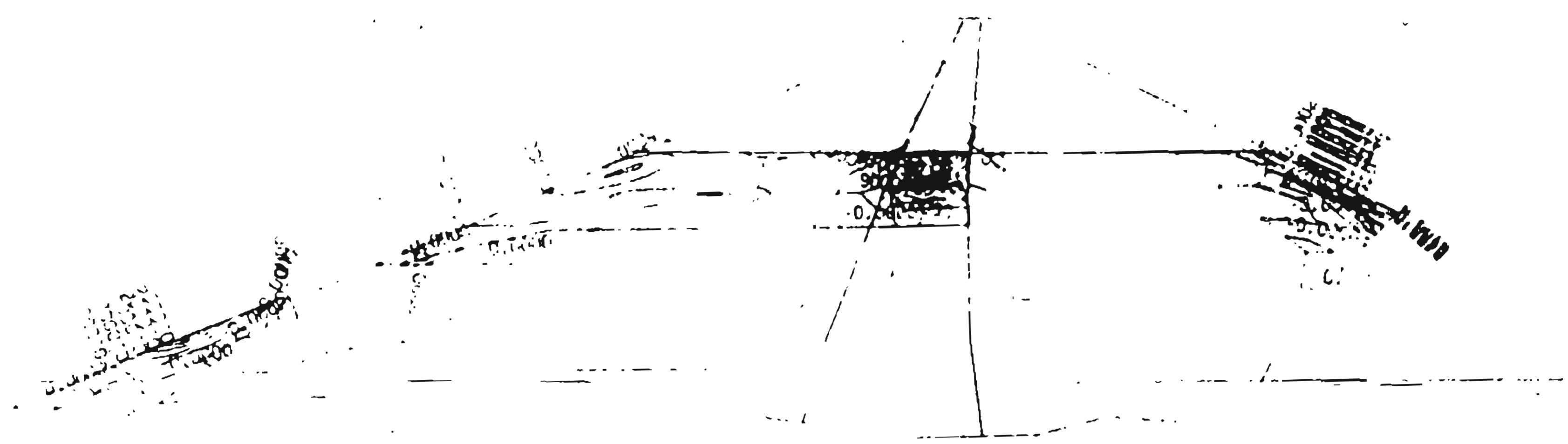


Fig.17 Contours for plastic strain - stage 3

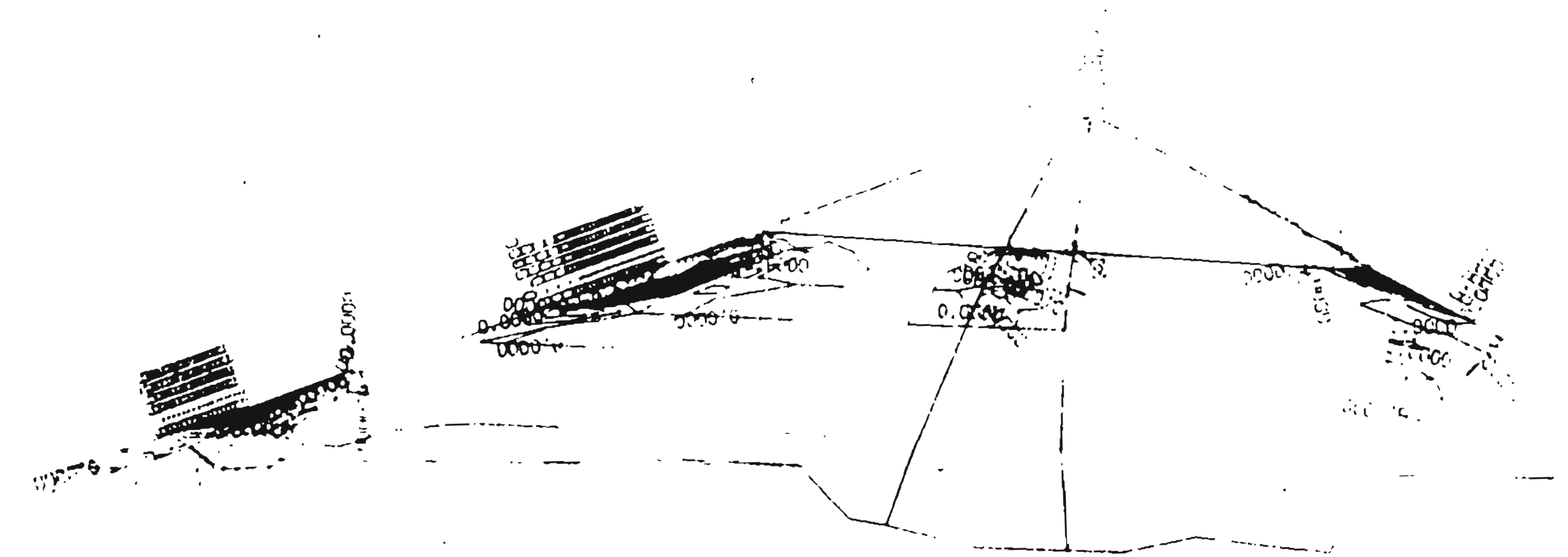


Fig. 18 Contours for plastic strain - stage 4

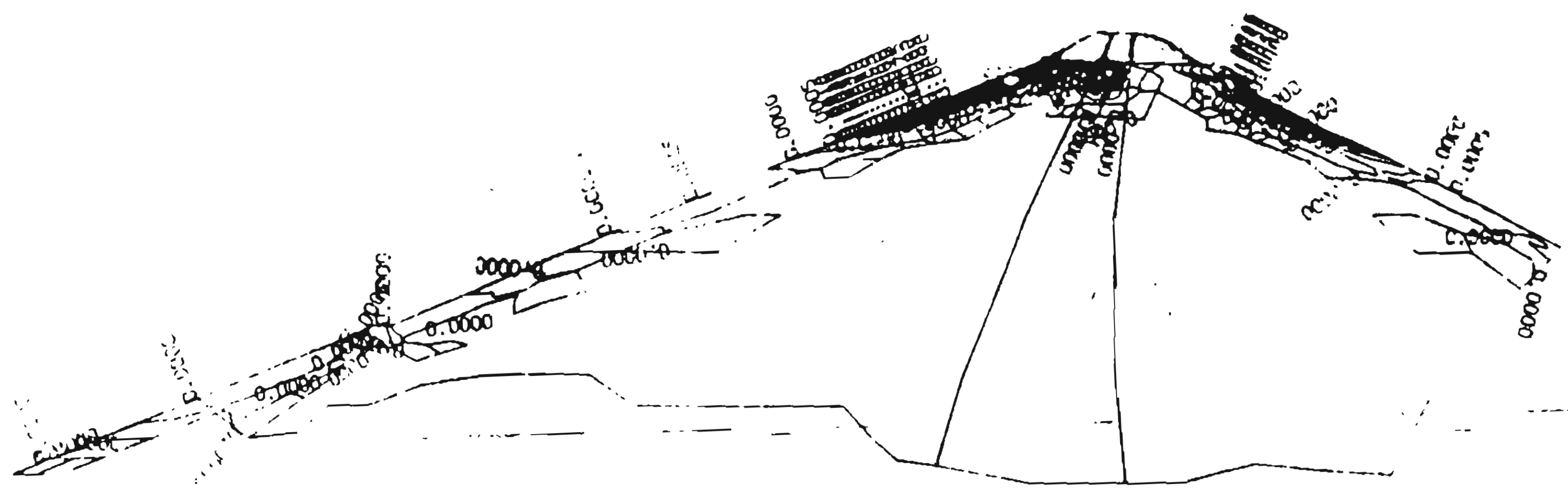


Fig.19 Contours for plastic strain - stage 5

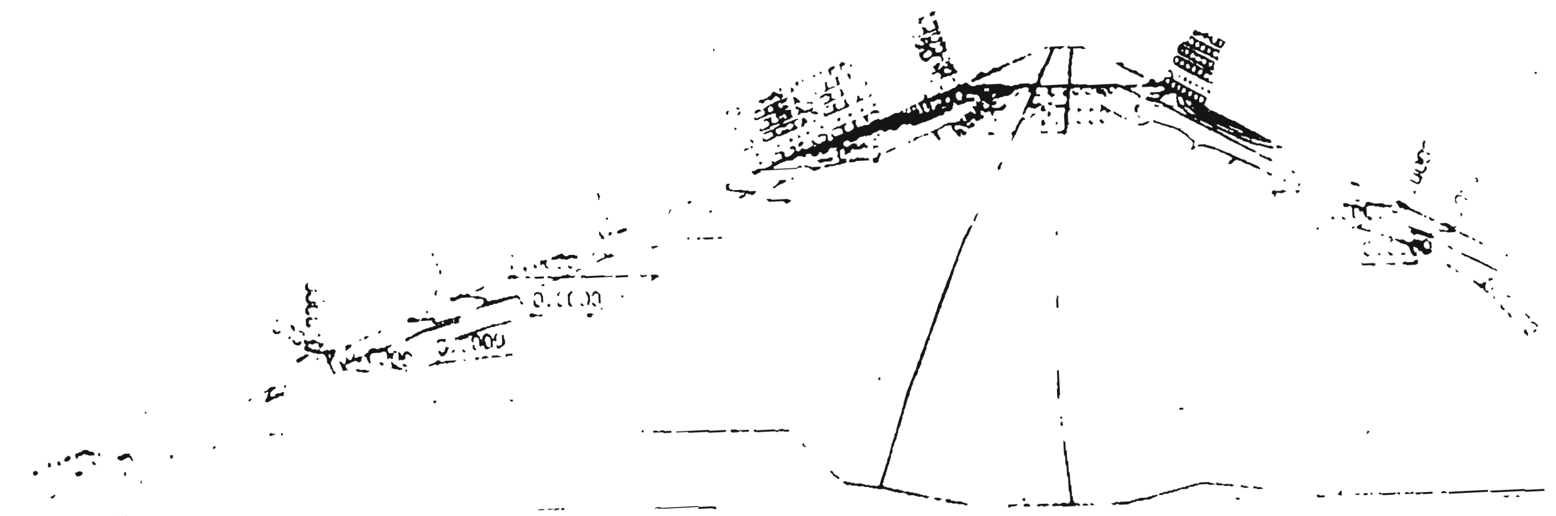


Fig.20 Contours for plastic strain - stage 6

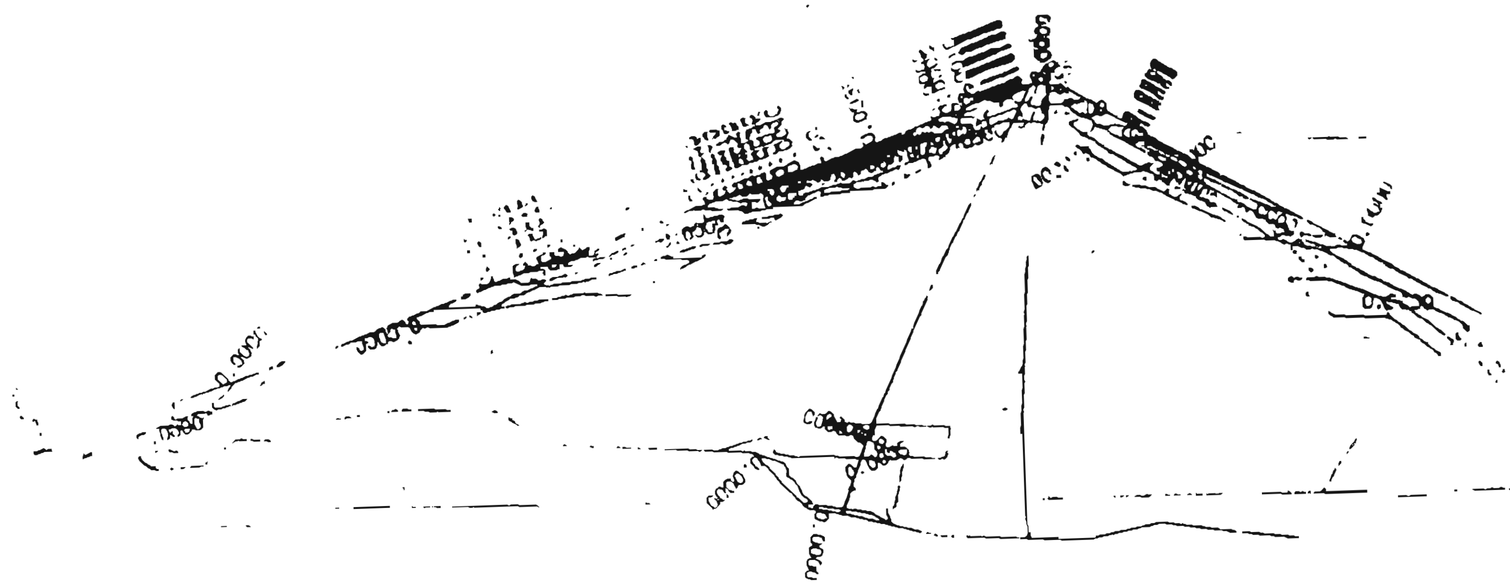


Fig.21 Contours for plastic strain - stage 7

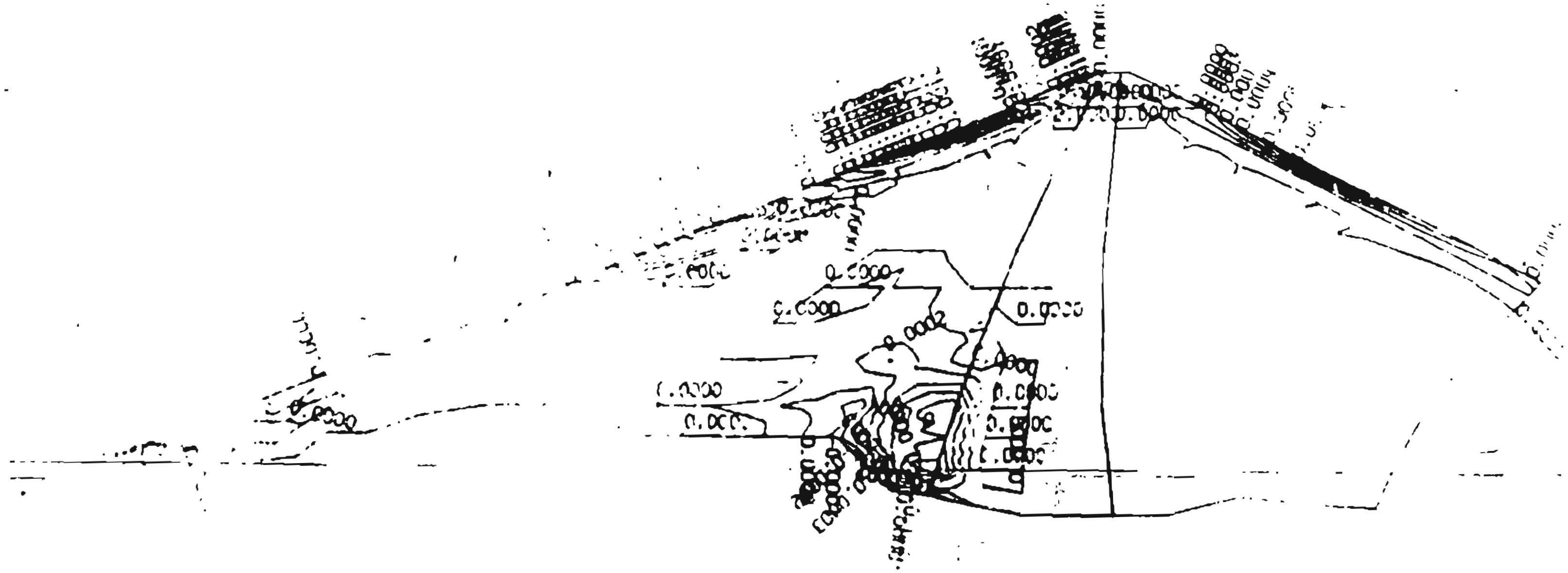
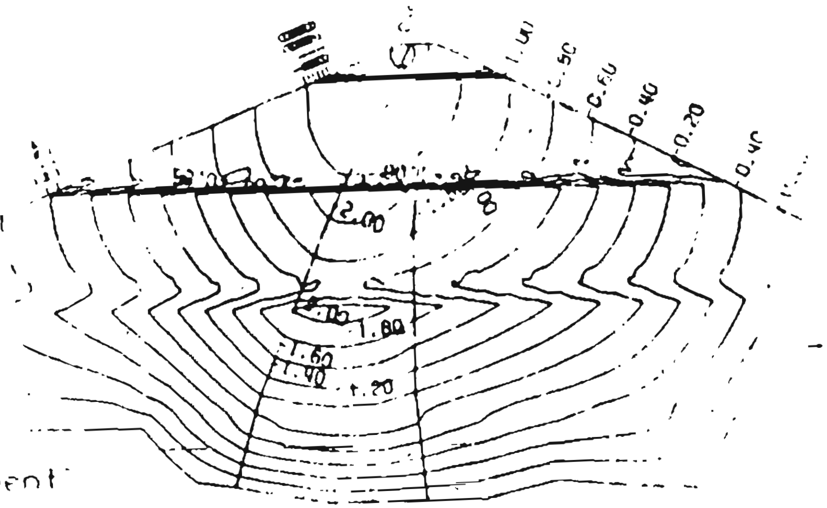


Fig.22 Contours for plastic strain - stage 8



(b) vertical displacement

Fig.23 Contours for vertical deformation after end of construction

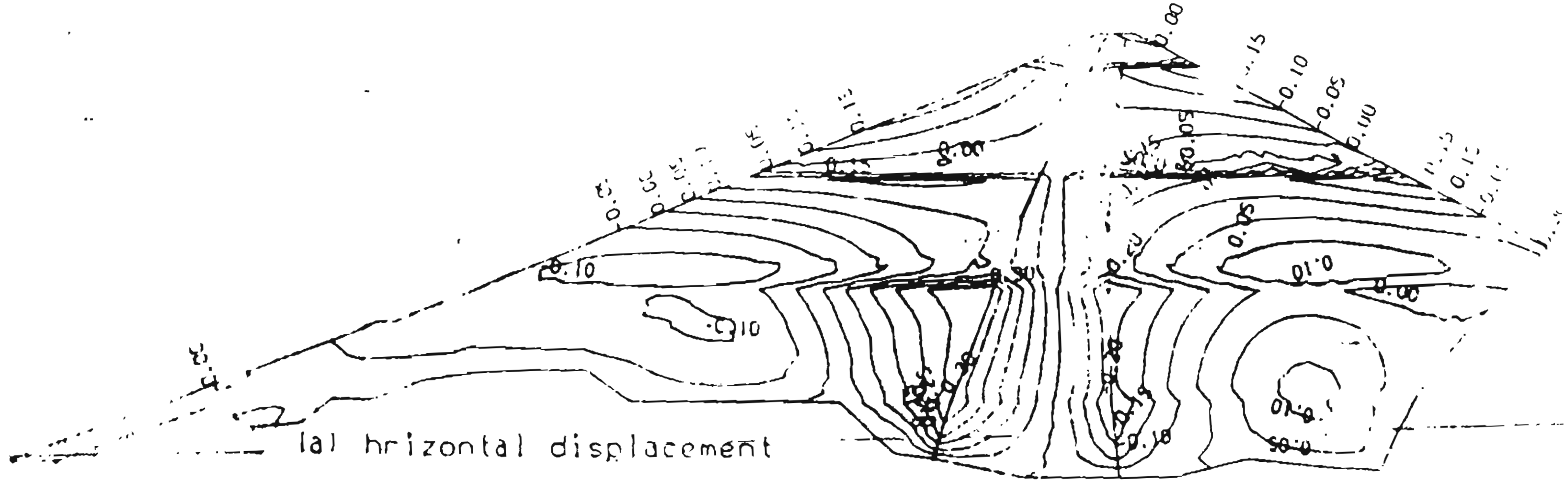


Fig.24 Contours for horizontal deformation after end of construction

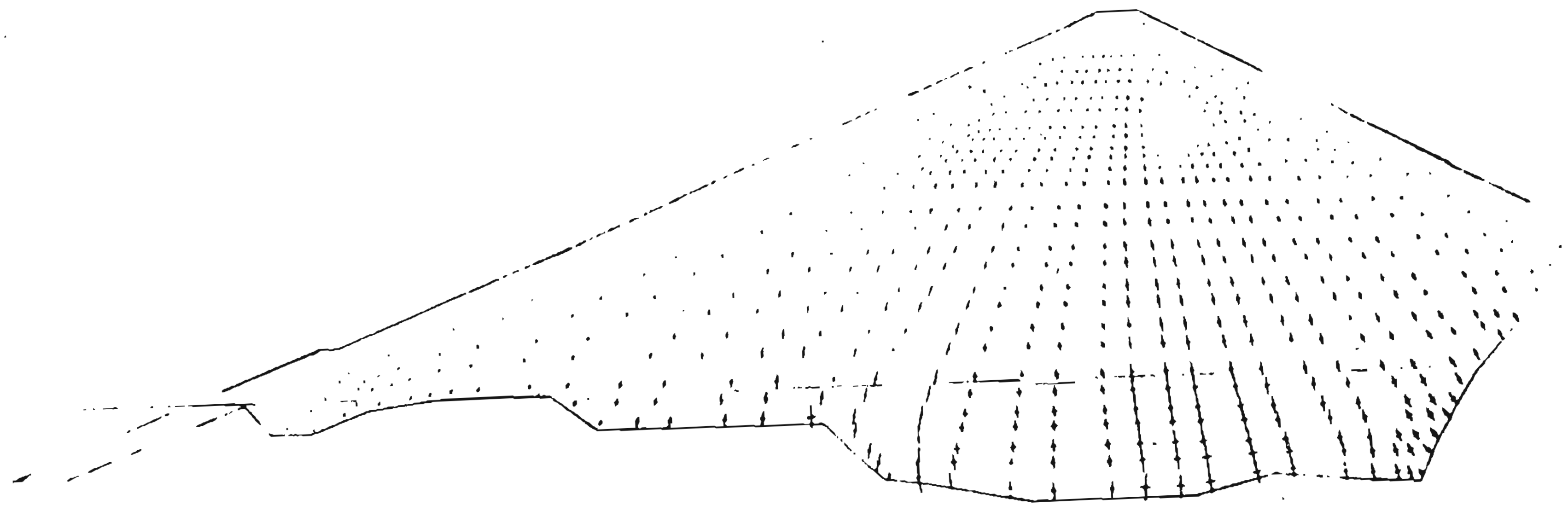


Fig.25 Direction and magnitude of principal stresses at the end of construction

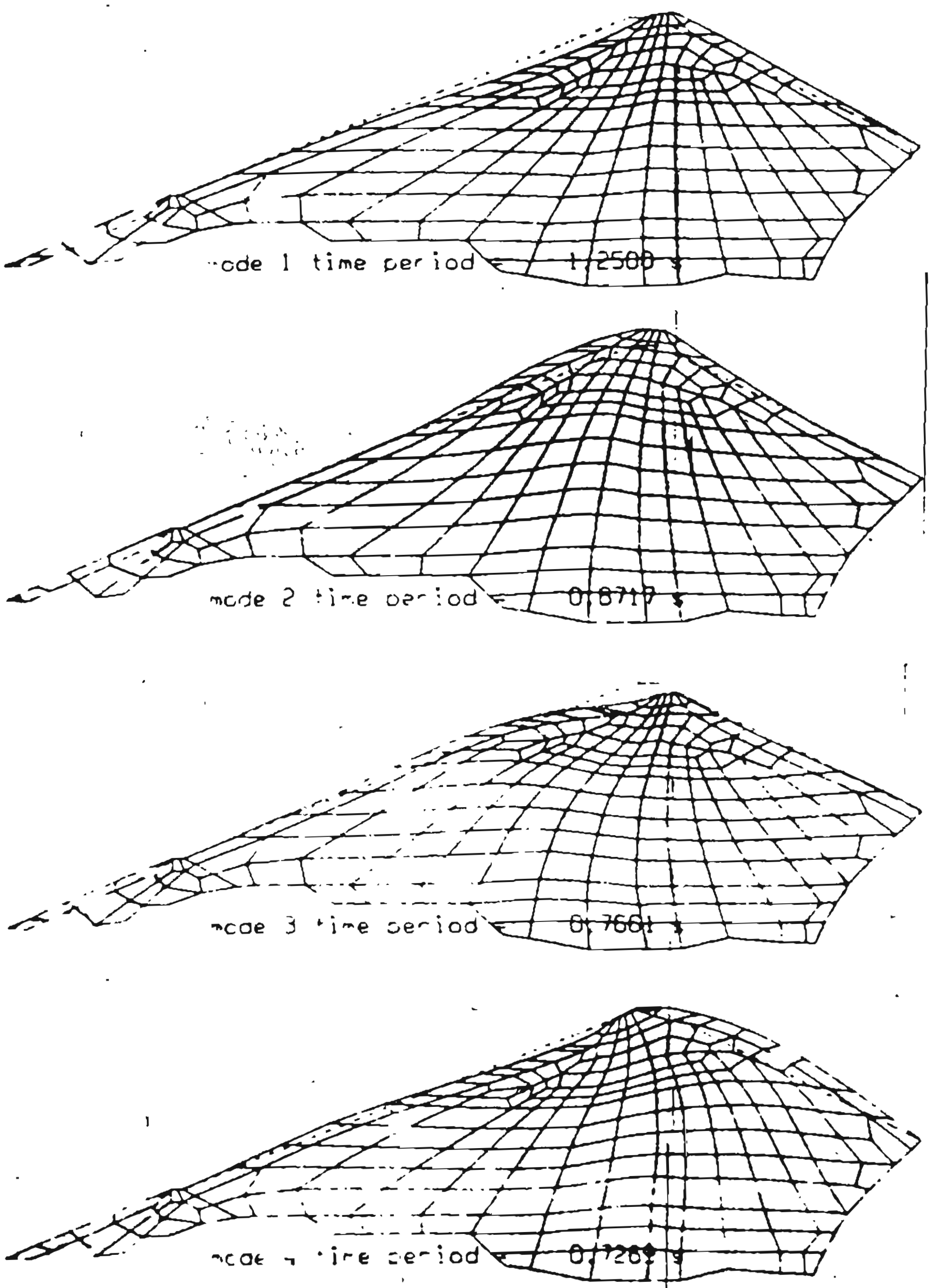


Fig.26 First four modes of vibration of the dam

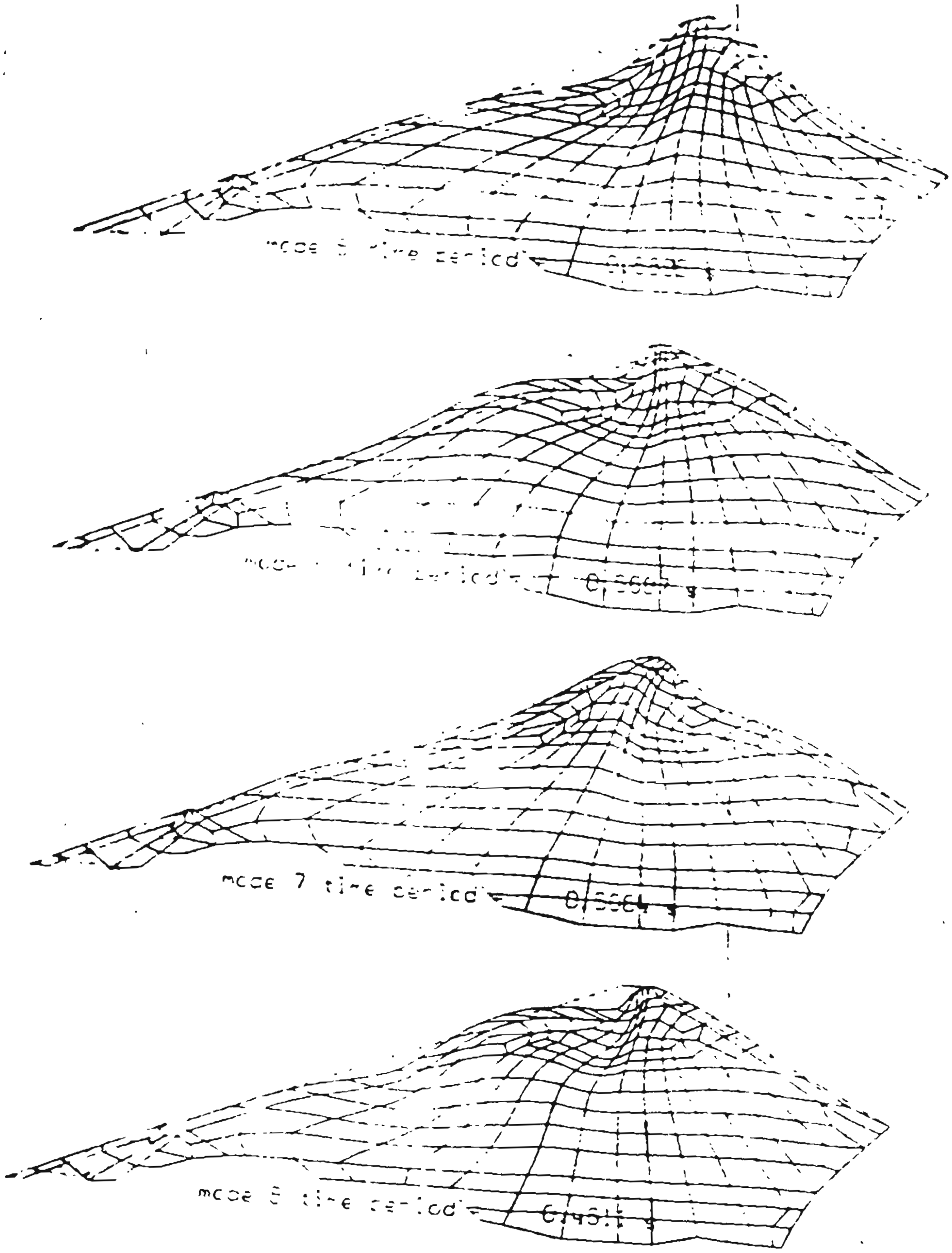


Fig 27 Five to eight modes of vibration of the dam

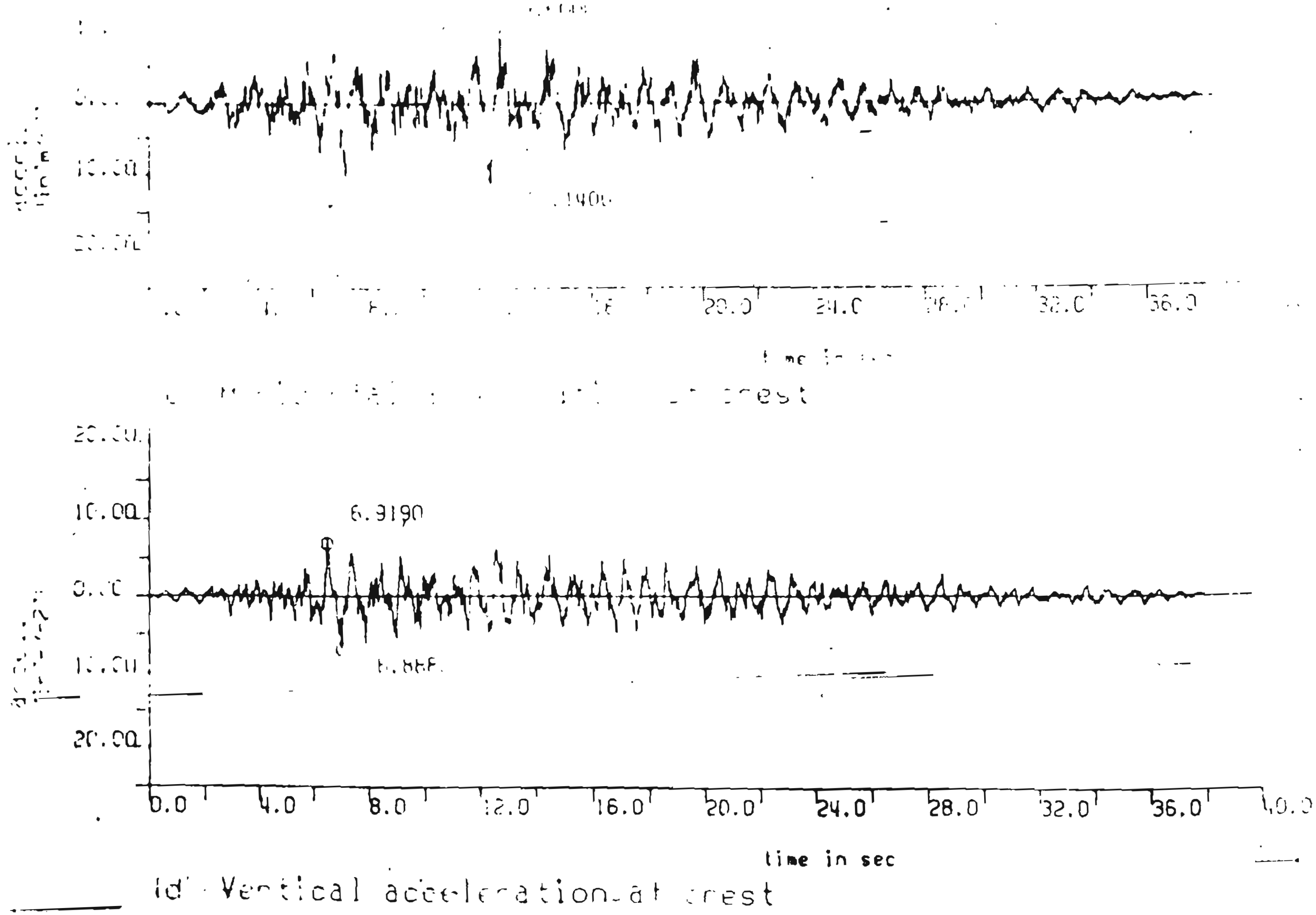
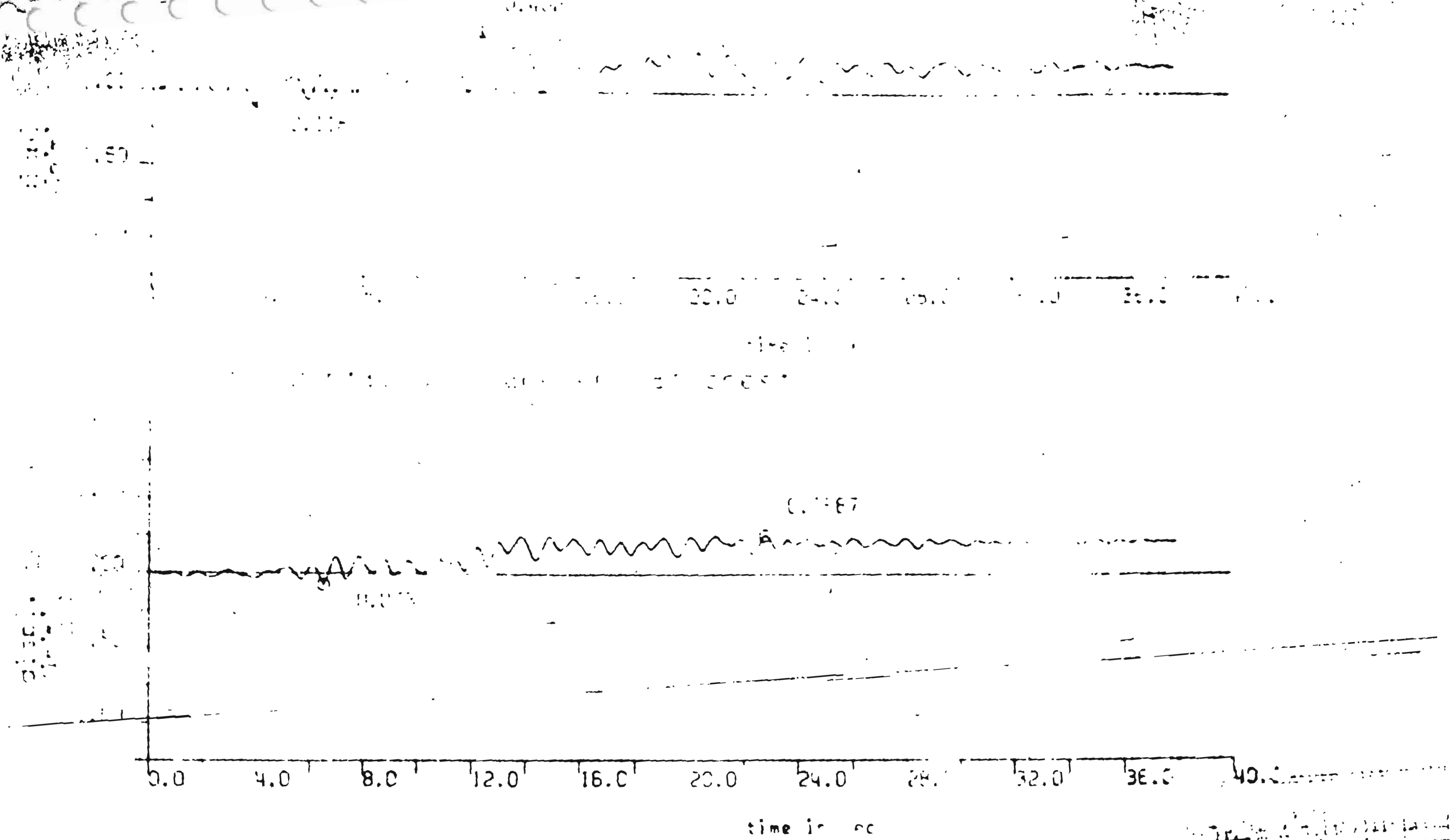
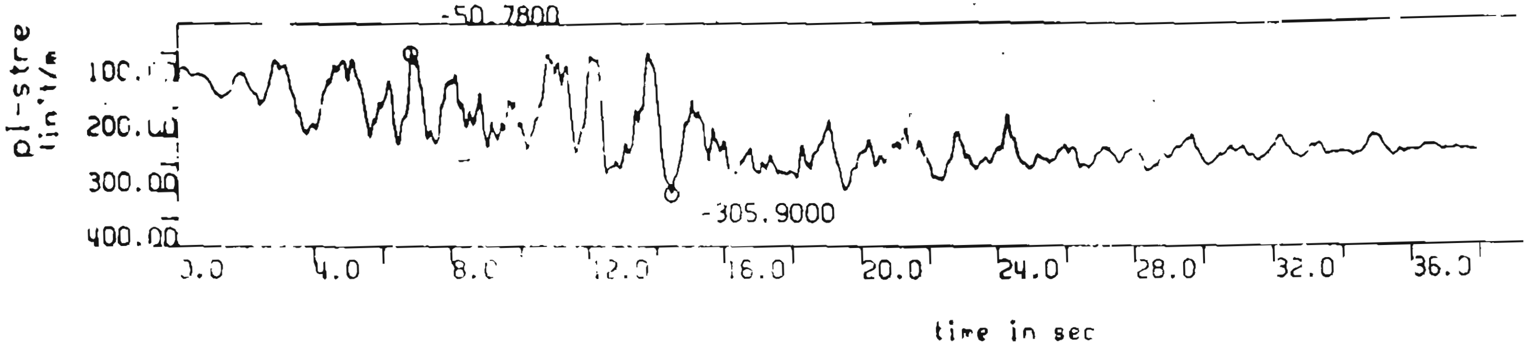


Fig.28 Time histories of horizontal and vertical acceleration at crest - nonlinear dynamic

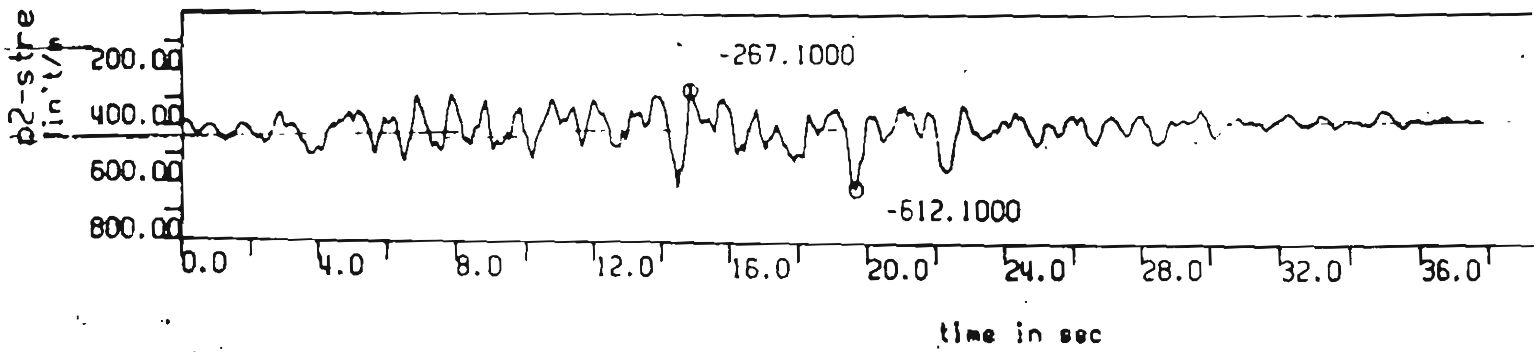


(b) Vertical displacement at crest (section c-1)

Fig.29 Time histories of horizontal and vertical displacement at crest - nonlinear dynamic



(c) P1 - stress history at the base



(d) P2 - stress history at the base

Fig.30 Stress history at the base of core - nonlinear dynamic

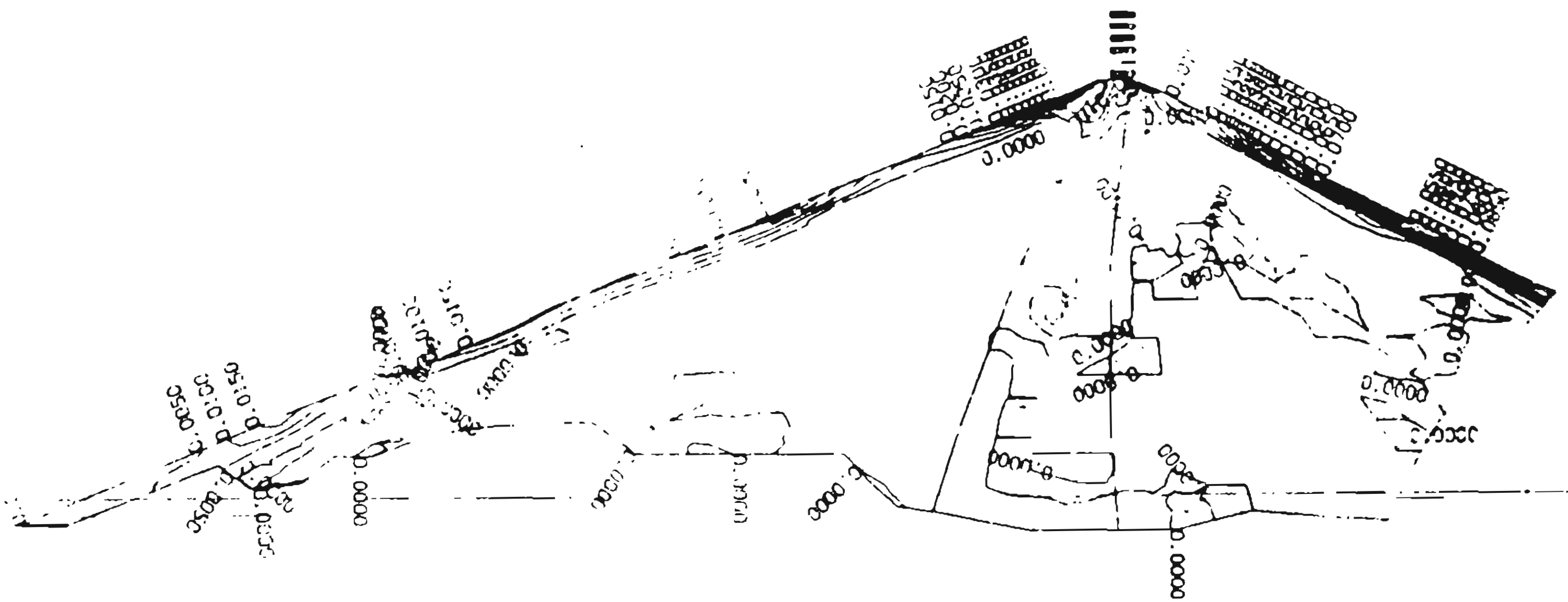


Fig.31 Plastic strain at the end of earthquake - nonlinear dynamic, T=1.25 sec

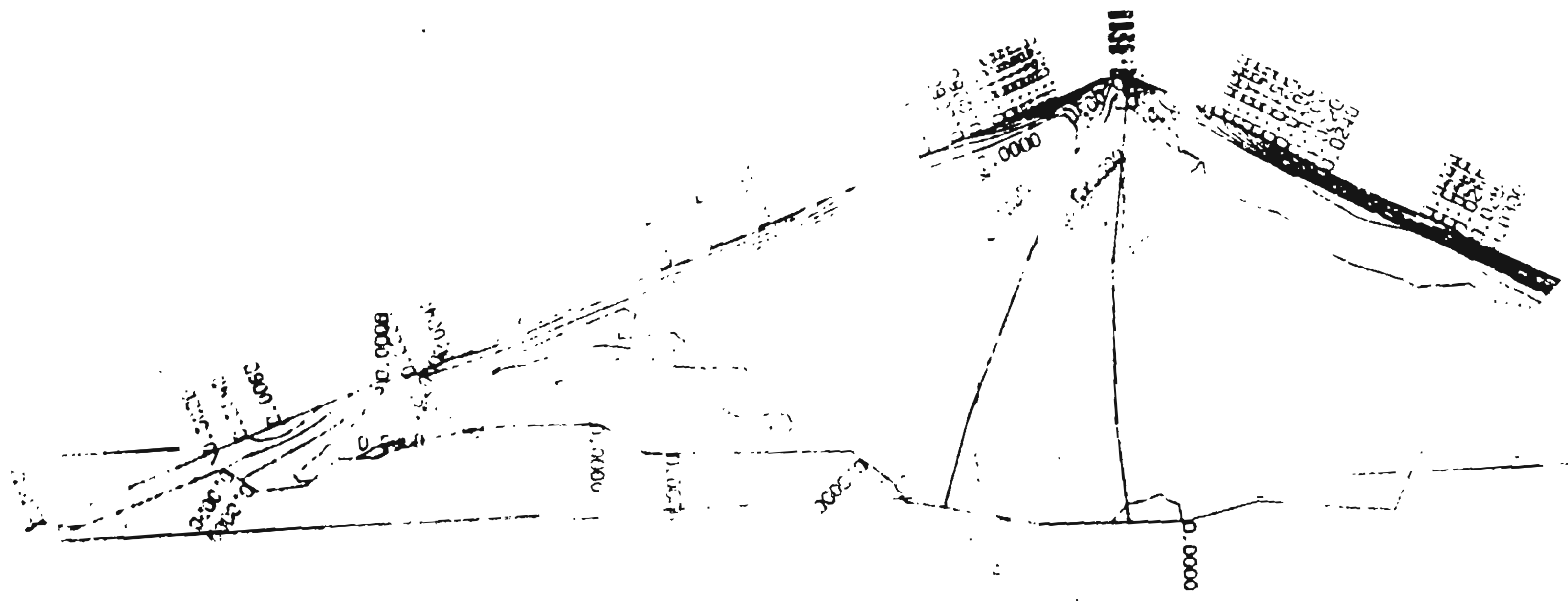


Fig.32 Volumetric strain at the end of earthquake - nonlinear dynamic, T=1.25 sec

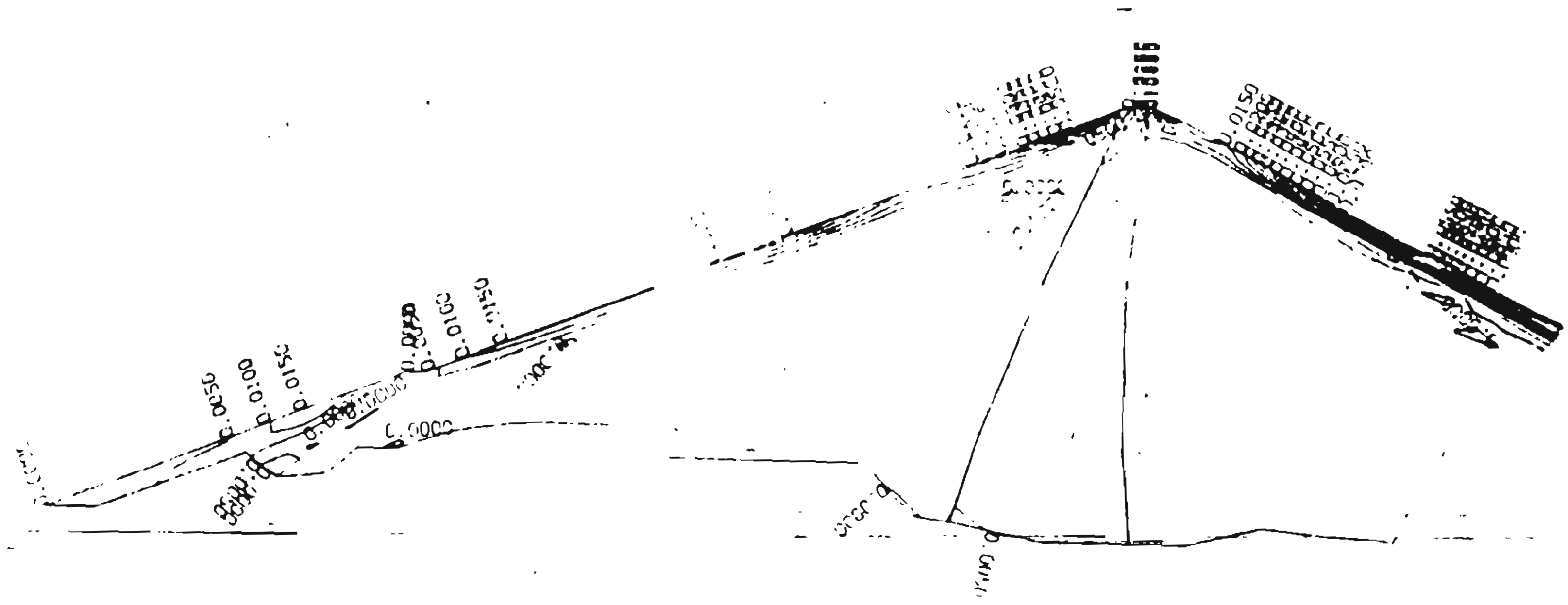


Fig.33 Major principal strain at the end of earthquake - nonlinear dynamic, T=1.25 sec

ANNEXURE-11

EARTHQUAKE ENGINEERING STUDIES EQ 98-02

MULTI LIFT NONLINEAR STATIC AND EARTHQUAKE RESPONSE ANALYSES OF 2D SECTION B-11 OF TEHRI ROCKFILL DAM

(supplementary report)

February, 1998

for official use only

DEPARTMENT OF EARTHQUAKE ENGINEERING
UNIVERSITY OF ROORKEE
ROORKEE, 247 667

CONTENTS

Preface

The study is a further extension of the earlier studies reported in reports EQ 98-02 entitled *2D Multilift Nonlinear Static and Earthquake Response Analyses of Tehri Rockfill Dam* and EQ 97-09 entitled *Multilift Nonlinear Static and Earthquake Response Analyses of 2D Section B-11 of Tehri Rockfill Dam*. This report describes the seismic response of Tehri dam subjected to simulated earthquake generated by Professor K. N. Khattri.

Among the ensemble of simulated earthquakes, Professor Khattri provided the digitised data of NS and vertical components of the accelerograms vide his letter dated 2nd January 1998.

The work was entrusted to Department of Earthquake Engineering, University of Roorkee, Roorkee. The above study has been carried out by Dr. D K Paul, Professor, Department of Earthquake Engineering.

February, 1998

(S. Basu)
Professor and Head

INTRODUCTION

This study is a further extension of the earlier work reported in Department of Earthquake Engineering (DEQ) reports EQ 98-02 and EQ 97-09 wherein the 2D plane strain nonlinear elasto-plastic earthquake response analysis of the Tehri dam for a postulated maximum credible earthquake (MCE) has been carried out for Sections B-11 and B-15 to asses the stability of the dam. For these analyses, earthquake motion has been taken to correspond 10% damping response spectra as recommended in DEQ report EQ 83-04 with a peak ground acceleration (PGA) pegged to 0.5g.

It was agreed to evaluate the seismic stability of the Tehri dam for one of the simulated earthquakes generated by Professor Khattri. Among the ensemble of simulated earthquakes, Professor Khattri provided the digitised data of NS and vertical components of the accelerograms.

This report therefore, describes the theoretical studies carried out to assess the seismic stability of the section B-11 of the Tehri rockfill dam which is found to have the maximum core depth of 243.5 *m* when subjected to the above simulated earthquake.

The response analysis of the dam is investigated by finite element method. Effect of variation of material properties with confining pressure is accounted for in the analysis. The initial static stresses in the dam required for the evaluation of earthquake response have been already obtained in EQ 98-02 and the same have been used in this analysis. The free vibration characteristics of the dam has also been evaluated, and therefore not repeated. Here, only the seismic response has been reported.

OBJECTIVE OF THE STUDY

To carryout the 2D nonlinear elasto-plastic dynamic analysis of the dam for a simulated earthquake and work out the maximum dynamic displacement and acceleration at the crest assuming the damping in the first two modes of vibration as 10%.

The 3D fundamental time period specified by Expert Group is 1.25 sec. The modulus of elasticity for 2D elasto-plastic dynamic analysis has to be modified in the square of the ratio of the fundamental time period of 3D and 2D free vibration analysis in order to match the fundamental time period of the 2D model of the dam with the 3D fundamental time period.

The acceleration time history of ground motion corresponds to simulated NS and vertical earthquakes provided by Professor Khattri having peak ground acceleration of 1.0204g and 0.8715g respectively.

To work out the earthquake response i.e. acceleration, displacement time histories at important locations, permanent crest settlement etc. for the simulated earthquake.

SECTION OF THE DAM

The detail of the Tehri dam has been described in DEQ report EQ-97-09. Since the valley is curved at the dam site and therefore a full cross section for plane strain analysis is not available. The analysis is carried out for the section which has the deepest core height. The deepest section is found to correspond to Section B-11. The detail can be found in EQ 98-02.

INPUT EARTHQUAKE GROUND MOTION

Simulated earthquakes have been generated by Professor Khattri for the Tehri site considering the local conditions at Tehri dam site. Among the ensemble of simulated earthquakes, Professor Khattri provided the digitised data of NS and vertical components of the accelerograms. Figures 1 and 2 show acceleration time history plots of the North and vertical components of the earthquakes having peak ground acceleration of 1.0204g and 0.8715g respectively. Figures also show the corresponding time history plots of ground velocity and displacement. The motion at the base of the dam is taken as the input motion for this analysis.

MATHEMATICAL MODEL AND DISCRETISATION OF THE SYSTEM

The geometry of the dam and zones identifying the different material properties is shown in Fig.3.

Finite Element Discretization: Plain strain idealization of the dam has been carried out. For the analysis eight noded isoparametric elements have been used. The discretization has been done to map the material boundaries. There are a total of 202 elements to map the entire dam section. The total number of nodes are 673. The nodes at the base of the dam are assumed to be fixed. The discretization of the dam is given in EQ 98-02. The Mohr-Coulomb yield criteria is used to model the nonlinear behaviour of soil

SOIL PROPERTIES

The shear modulus at a confining pressure and shear strain level is determined from tests on rockfill. It can be determined at any other confining pressure and shear strain level. Consideration of the confining pressure, the stiffness of dam increases with depth. To take into this variation in the dam analysis, a power law variation of shear modulus has been used as described in DEQ report EQ 98-02. This variation in material properties corresponds to a variation of very small shear wave velocity at the surface to 437.9 m/s at a depth of 250 m in the shell material. An average value of shear wave velocity in the shell works out to about 315.0 m/s. For the core material, these values at a depth of 250 m works out to 350.0 m/s with an average value of 250 0 m/s.

The material properties taken for the rockfill dam analysis are listed in Table 1

Table-1 Material properties

sl. no.	property	shell	rip-rap	core
1	shear modulus, G (t/m^2)	6000.0	6000.0	3000 0
2	modulus of elasticity (t/m^2) at 10(t/m^2) confining pressure	0.162e+05	0.150e+05	5400
3.	Poison's ratio	0.35	0.25	0.30
4.	moist density (t/m^3)	2.45	2.00	2.00
5.	saturated density(t/m^3)	2.49	2.16	2.15
6.	dry density (t/m^3)	2.36	1.80	1.85
7.	cohesion, c (t/m^2)	7.00	0.50	5.00
8.	effective angle of internal friction (degree)	42.0	42.0	28.0
9.	power variation of G, m	0.5	0.5	0.3

The dynamic modulus of elasticity has been taken such that the fundamental time period of vibration of dam is 1.25 sec i.e. the static modulus of elasticity is multiplied by a factor $(2.2427/1.25)^2 = 3.219$, where 2.2427 sec is the time period of Section B-11 obtained with the static material properties. For dynamic analysis saturated unit weight has been taken for the u/s shell elements.

ELASTO-PLASTIC ANALYSIS

In the analysis, the stress-strain relation which exhibit an elasto-plastic behaviour of soil is considered where the elasto-plastic behaviour follow the Mohr-Coulomb yield criterion. The detail of analysis is described in Ref. 3.

The response evaluation provides time histories of stress, displacement and acceleration at desired locations/elements during the earthquake.

ANALYSIS OF THE DAM

Static and earthquake response analyses of Section B-11 is carried out to study the stability of dam.

Determination of initial static stresses: Analysis of the high rockfill dam is carried out for static loads due to self weight, water pressure and uplift. In the nonlinear static analysis it is convenient to use incremental procedure to permit simulation of actual sequence of events involved in the construction and loading of the dam. They also permit simulation of nonlinear and stress-dependent behaviour of the rock fill. Eight stages of construction and reservoir fillings have been considered. The detail of the analysis is given in EQ 98-02.

Frequency analysis: The frequency analysis has also been carried out to study the free vibration characteristics of the dam based on the final stress distribution obtained from nonlinear static analysis as reported in EQ 98-02.

Earthquake response analysis Earthquake response is evaluated for the simulated earthquake considering the initial static stresses in the embankment. Response of the dam includes the evaluation of stresses, acceleration and displacement histories at important locations.

RESULTS AND DISCUSSIONS

The nonlinear dynamic analysis has been carried out for the simulated ground motion at Tehri dam site. Figure 4 shows the time history of horizontal and vertical accelerations at the crest obtained from non-linear analysis and their peak values are 13.80 m/s^2 (1.407g) and 16.53 m/s^2 (1.685g) respectively. Figure 5 shows the time history of horizontal and vertical displacements at the crest and their peak values are 58.92 cm and 119.80 cm respectively. Figure 6 shows the time history of principal stresses at the base of the core. Table 2 gives the comparison of earthquake response of the dam for the DEQ and the Khattri's earthquakes.

Figures 7-9 show the plastic strains, major principal strains and volumetric strains developed in the dam body at the end of the earthquake. It is seen that the a very small portion of the core at the top undergo plastic strain and the maximum plastic strain is found to be 0.10. It also seen that most of the plastic strains are confined mainly to u/s and d/s surfaces of the dam.

Table -2 Comparison of earthquake response for the Section B-11 for the DEQ and the Khattri's earthquakes

sl. no	.parameters	DEQ earthquake	Khattri earthquake
1.	horizontal acceleration at dam crest (m/s2)	11.14	13.80
2.	vertical acceleration at dam crest (m/s2)	6.90	16.53
3.	horizontal displacement at dam crest (cm)	40.25	58.92
4.	vertical displacement at dam crest (cm)	25.87	119.80

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3. ------(1997), 2D Multi Lift Nonlinear Static and Earthquake Response Analyses of Tehri Rockfill Dam, Report no. EQ 97-09, Earthquake Engineering Studies, University of Roorkee, Roorkee

4. ------(1998), Multi Lift Nonlinear Static and Earthquake Response Analyses of 2D Section B-11 of Tehri Rockfill Dam, Report no. EQ 98-02, Earthquake Engineering Studies, University of Roorkee, Roorkee

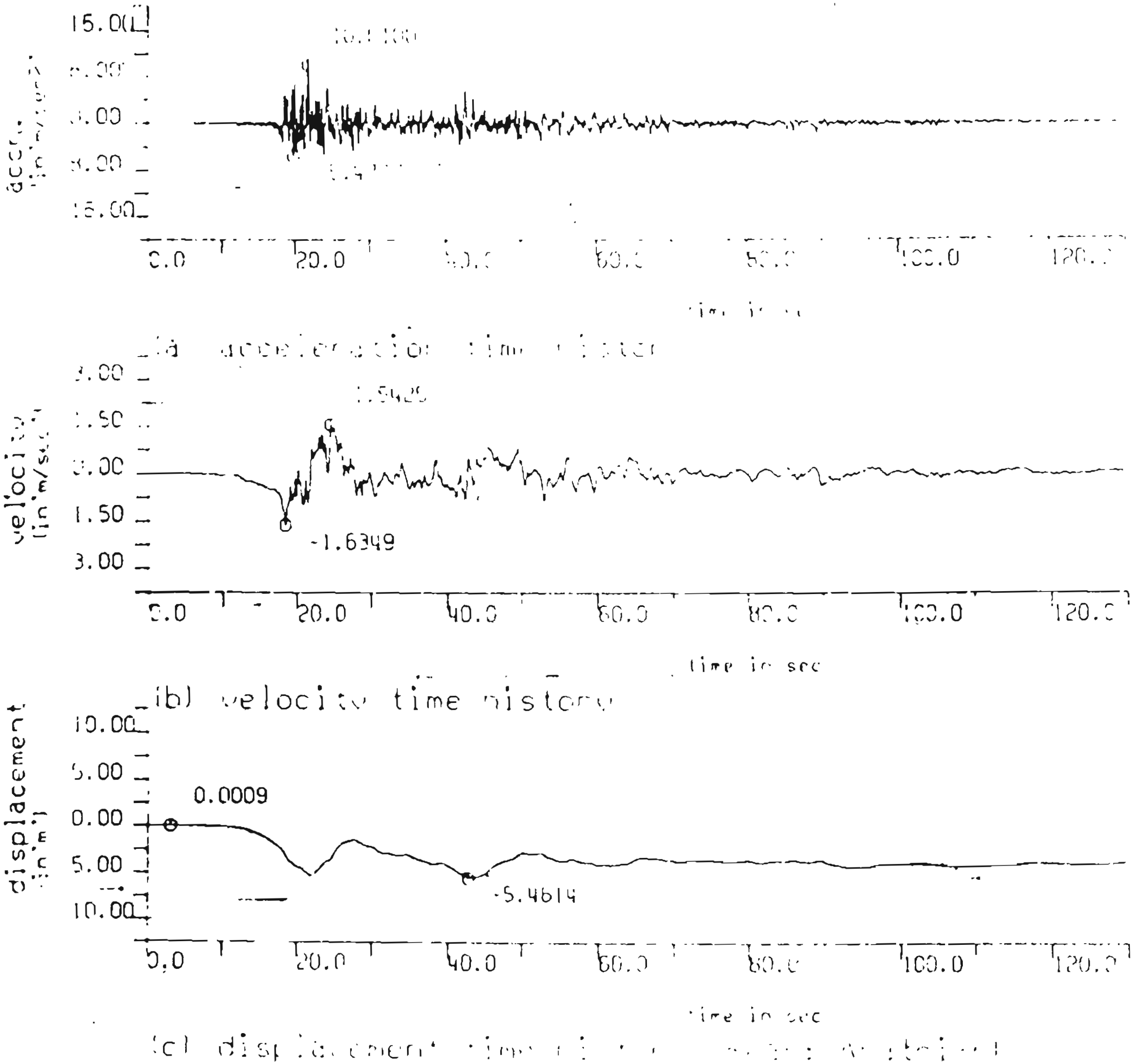


Fig.1 Displacement, velocity and acceleration time history N-component - Khattri

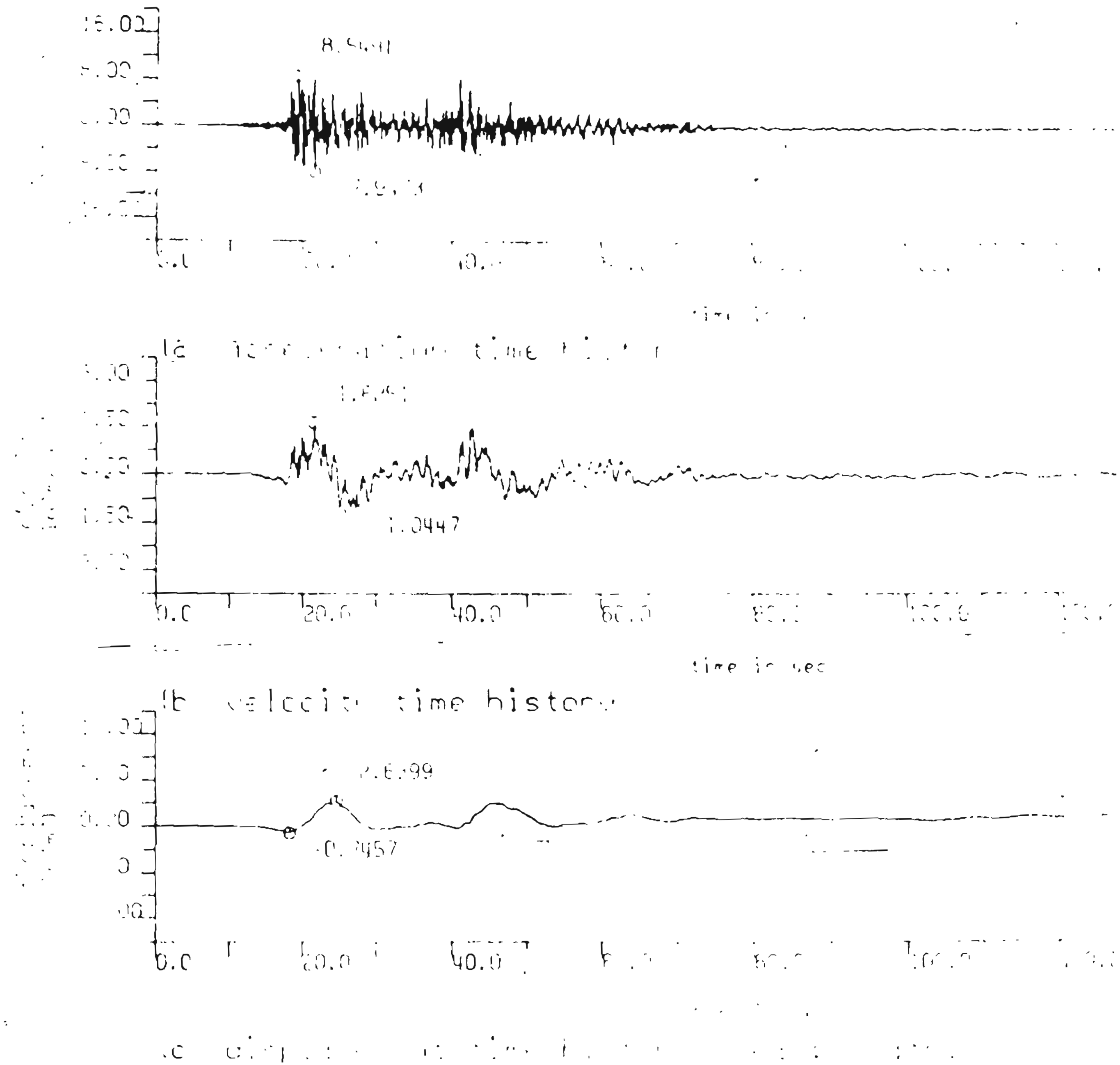


Fig.2 Displacement, velocity and acceleration time history vertical component Khatn

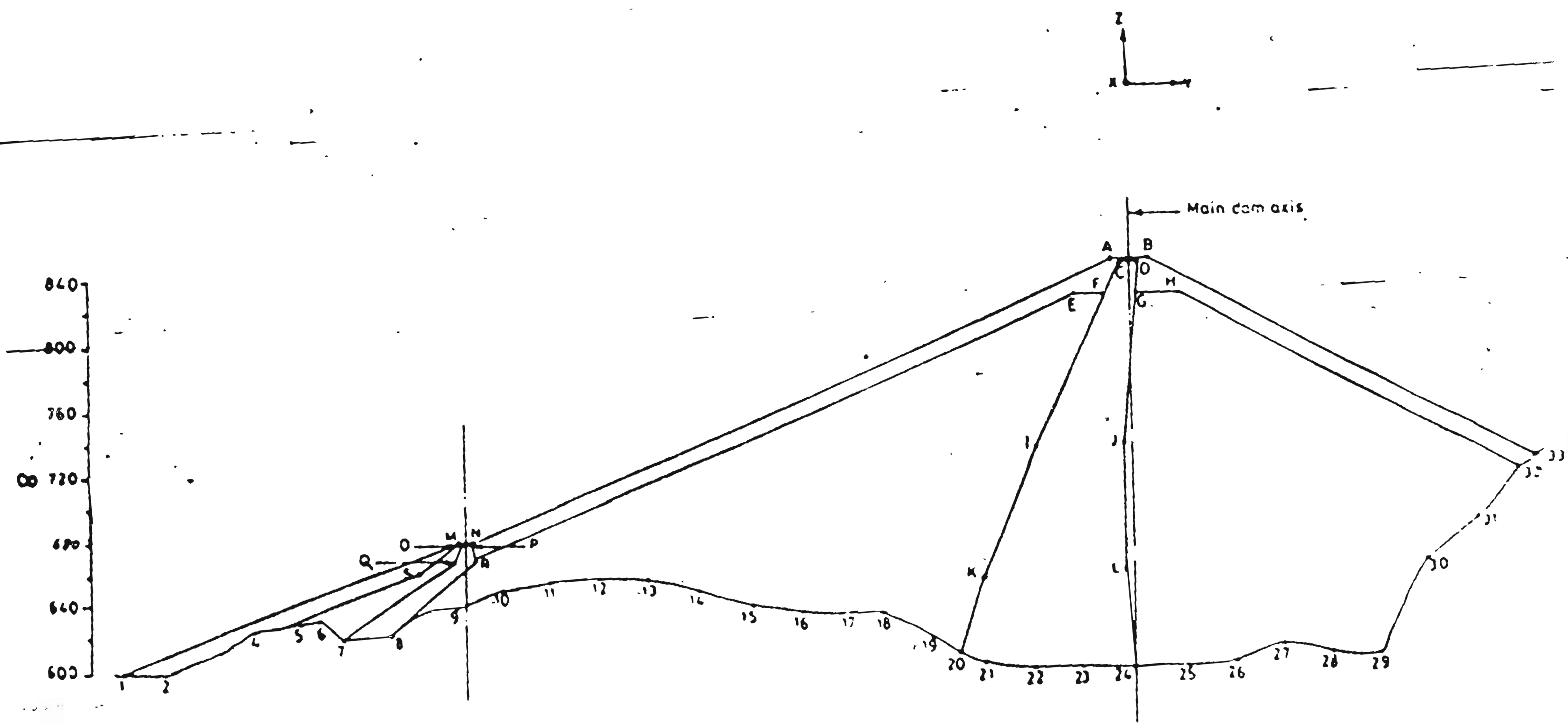
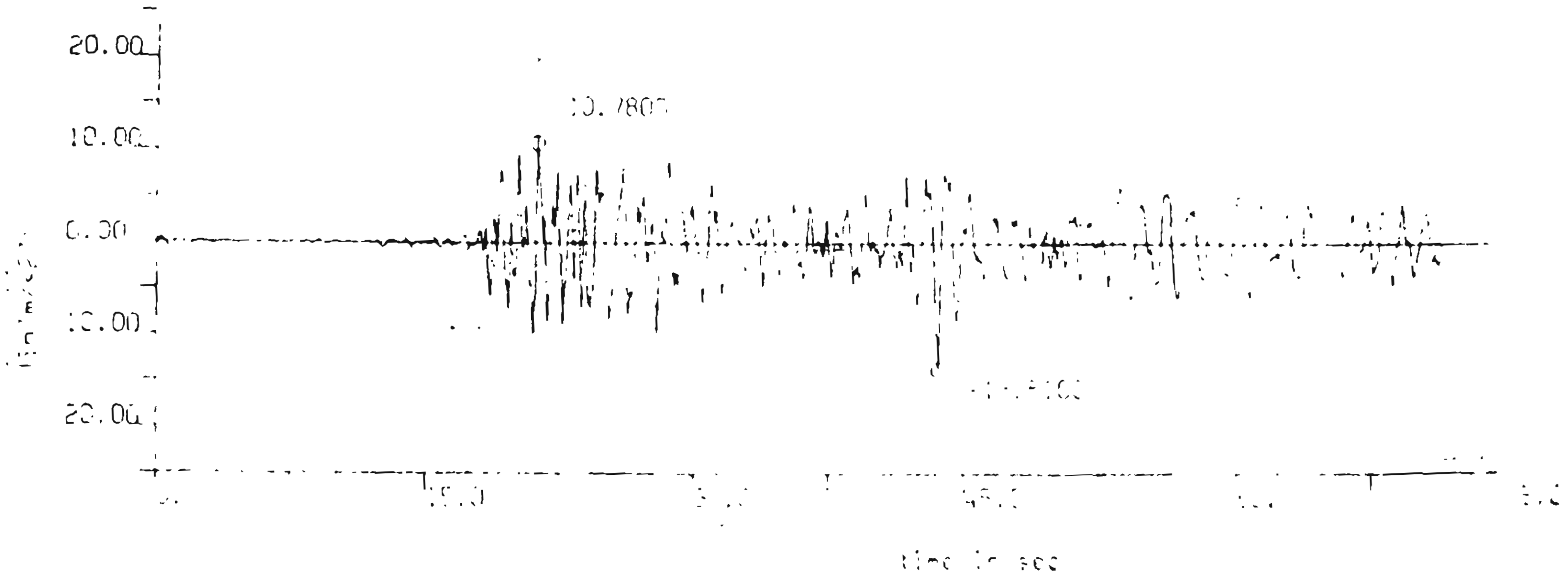
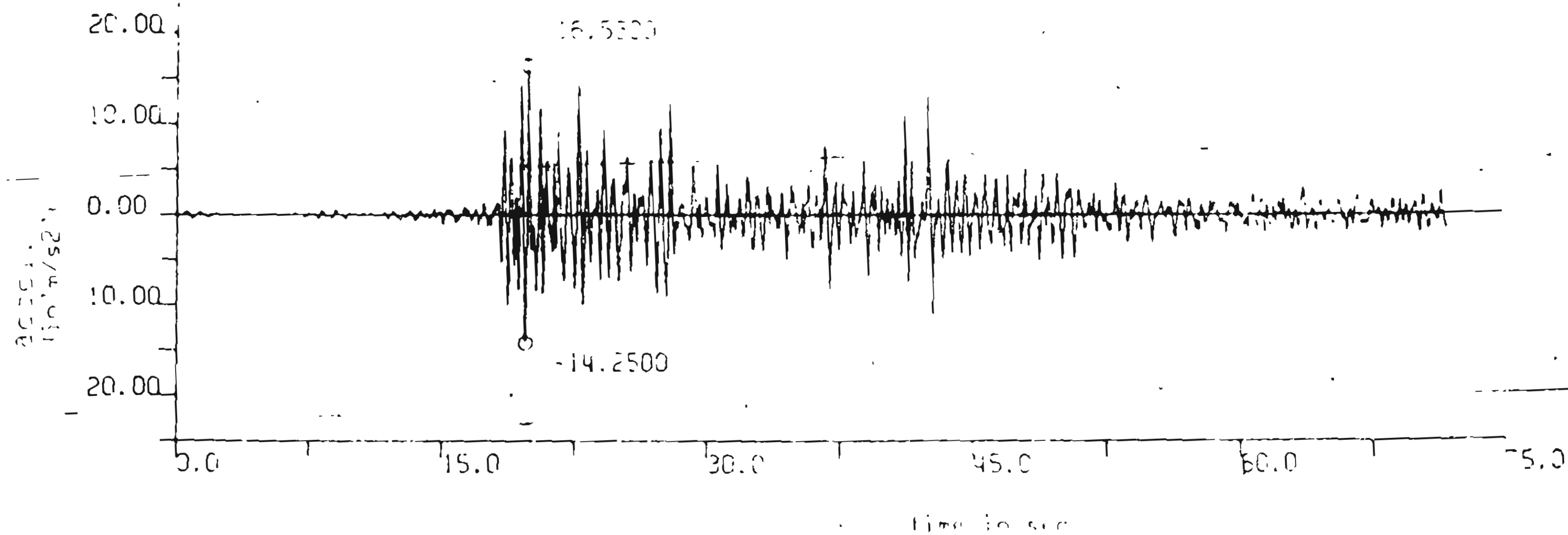


Fig 3 2D dam section at B-11 with maximum core height provided by THDC



(c) Horizontal acceleration at crest



(d) Vertical acceleration at crest

Fig 4 Time histories of horizontal and vertical acceleration at crest - nonlinear dynamic

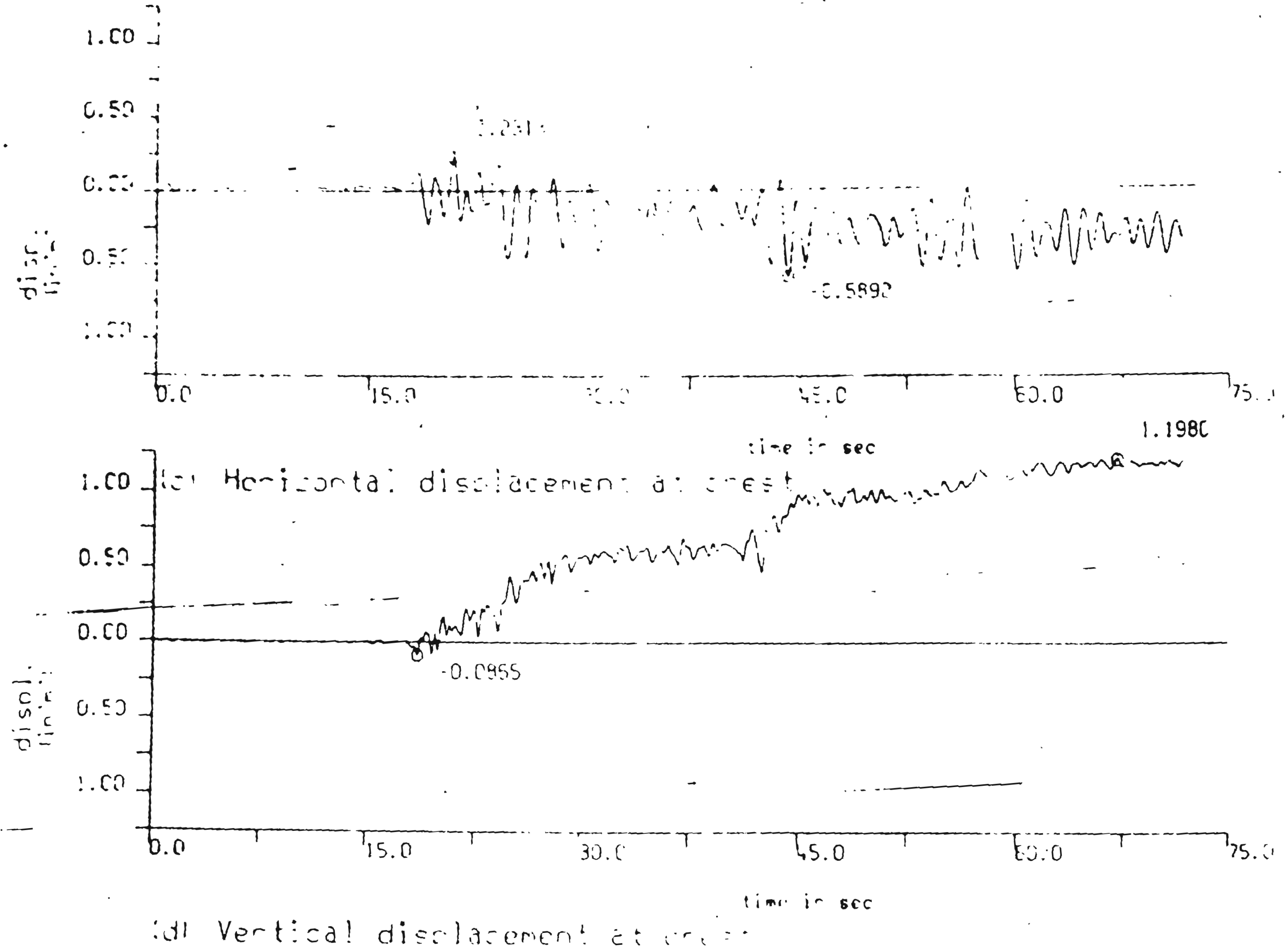
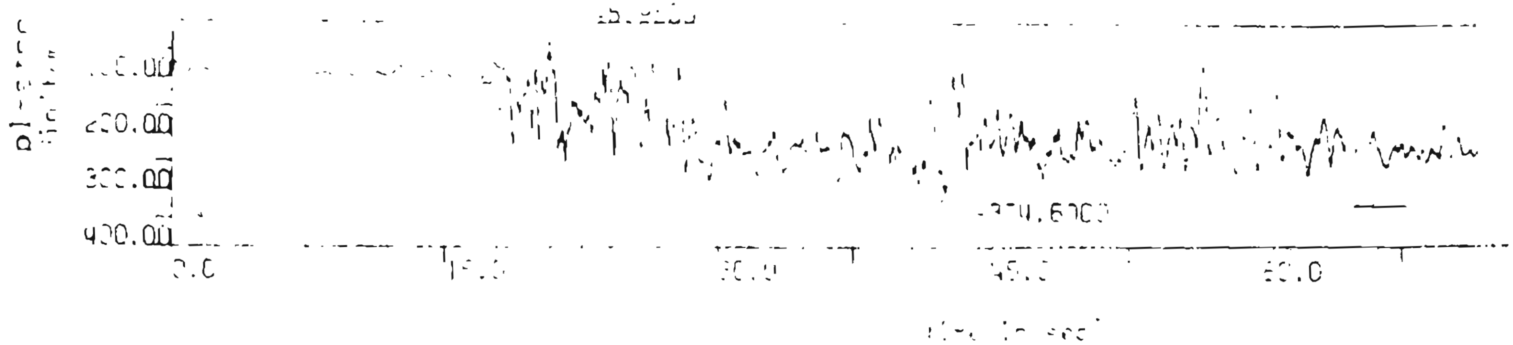
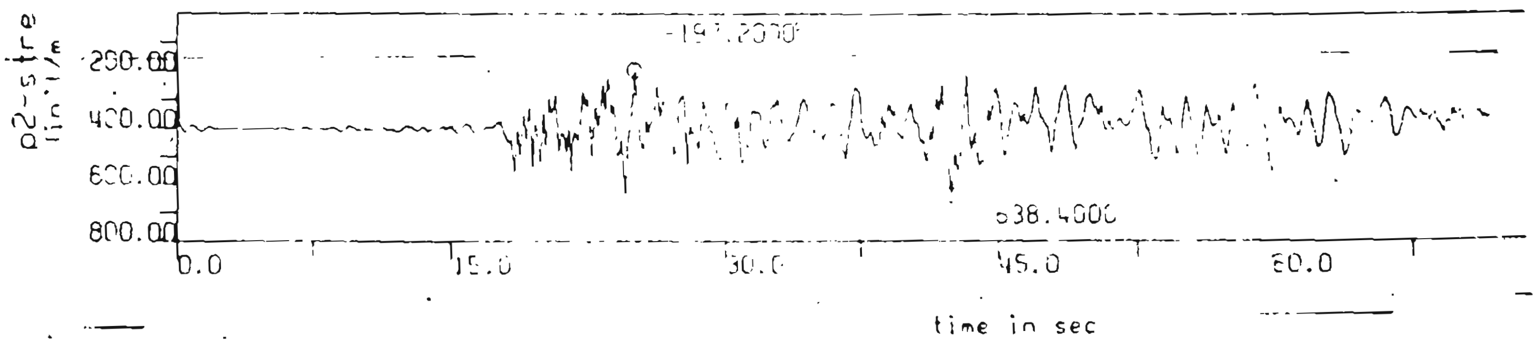


Fig.5 Time histories of horizontal and vertical displacement at crest - nonlinear dynamic



(c) P1 - stress history at the base



(d) P2 - stress history at the base

Fig.6 Stress history at the base of core - nonlinear dynamic

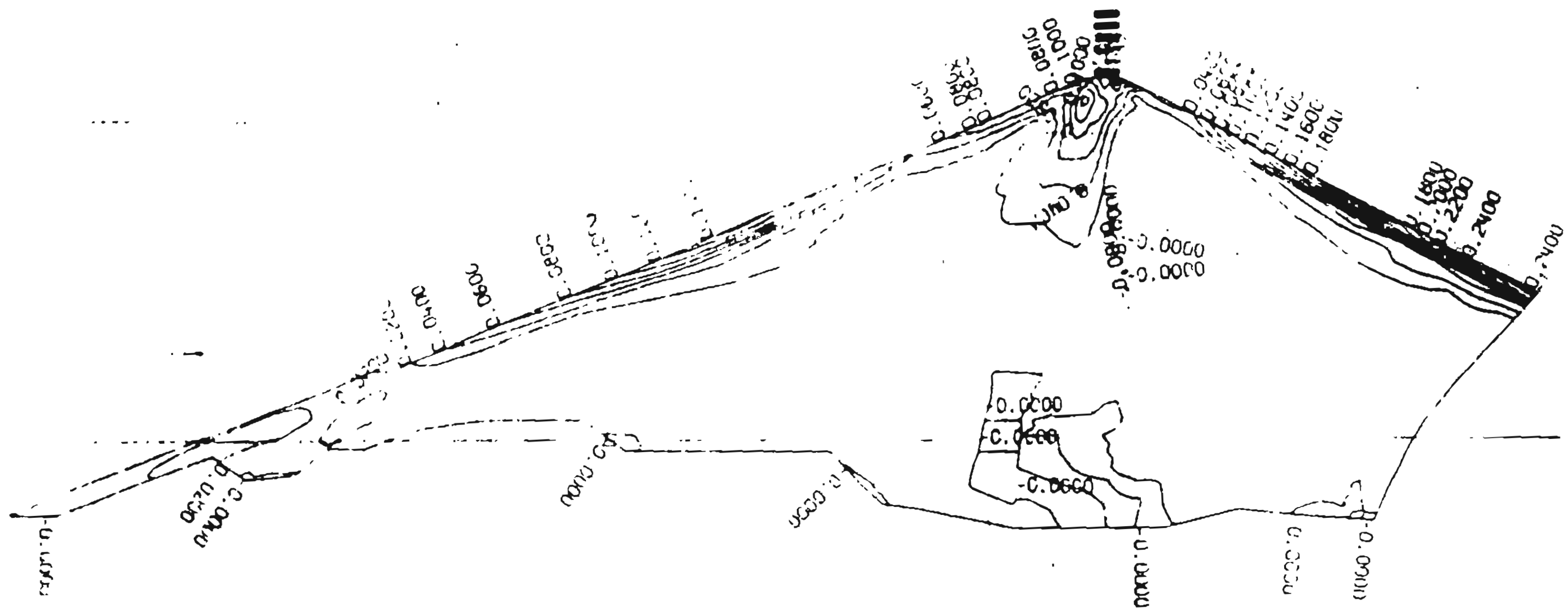


Fig.7 Plastic strain at the end of earthquake - nonlinear dynamic, T=1.25 sec

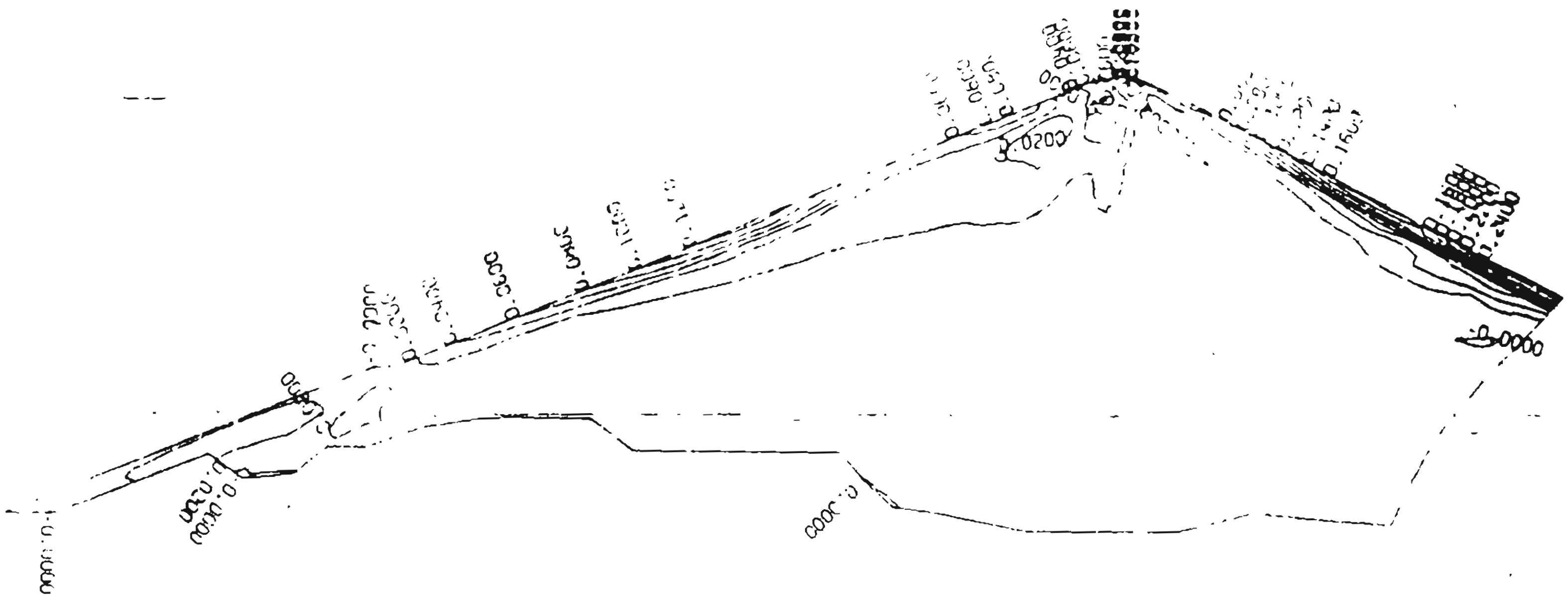


Fig.8 Major principal strain at the end of earthquake - nonlinear dynamic, T=1.25 sec

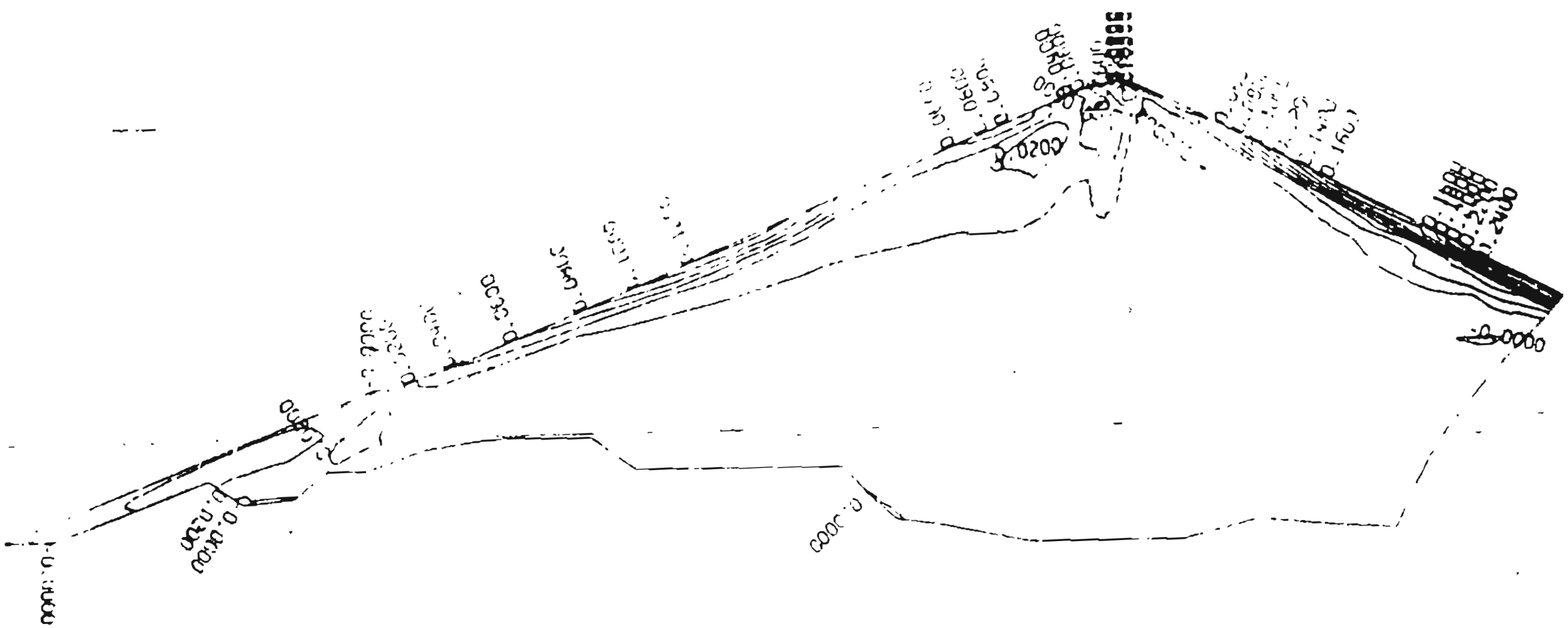


Fig.8 Major principal strain at the end of earthquake - nonlinear dynamic, T=1.25 sec

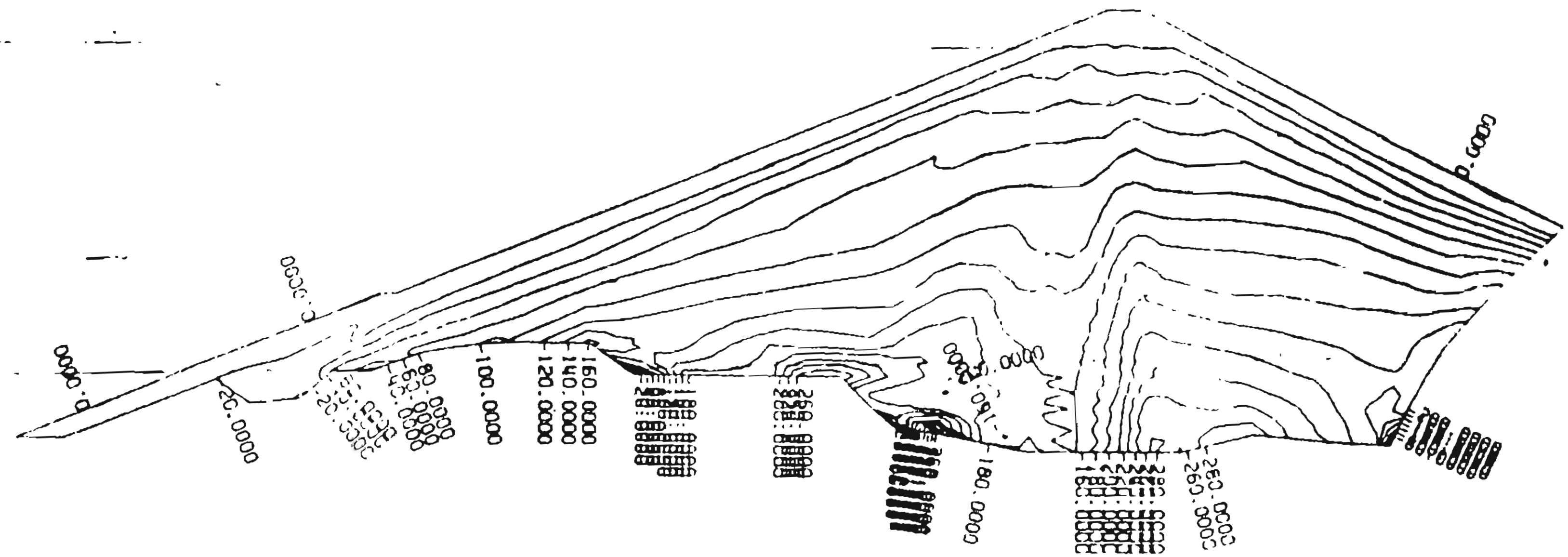


Fig.10 Countours of sigma -z stress (section b-11, Khattri earthquake)

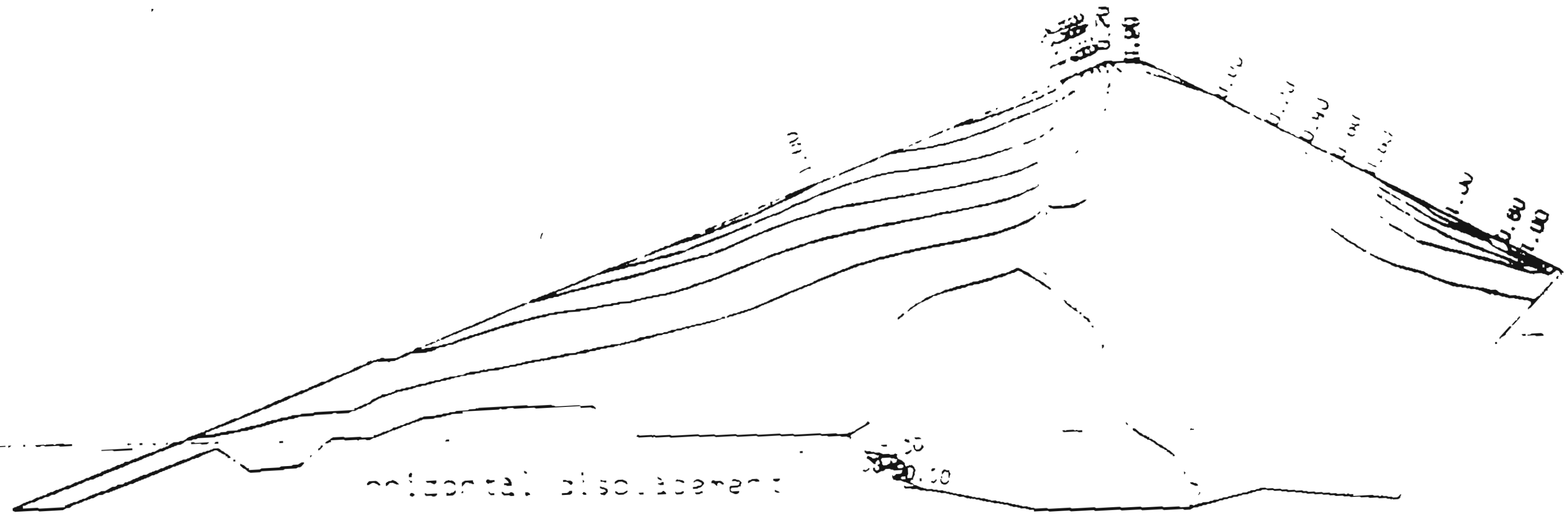


Fig.11 Countours of horizontal displacement at the end of earthquake
(section b-1.1, Khattri earthquake)

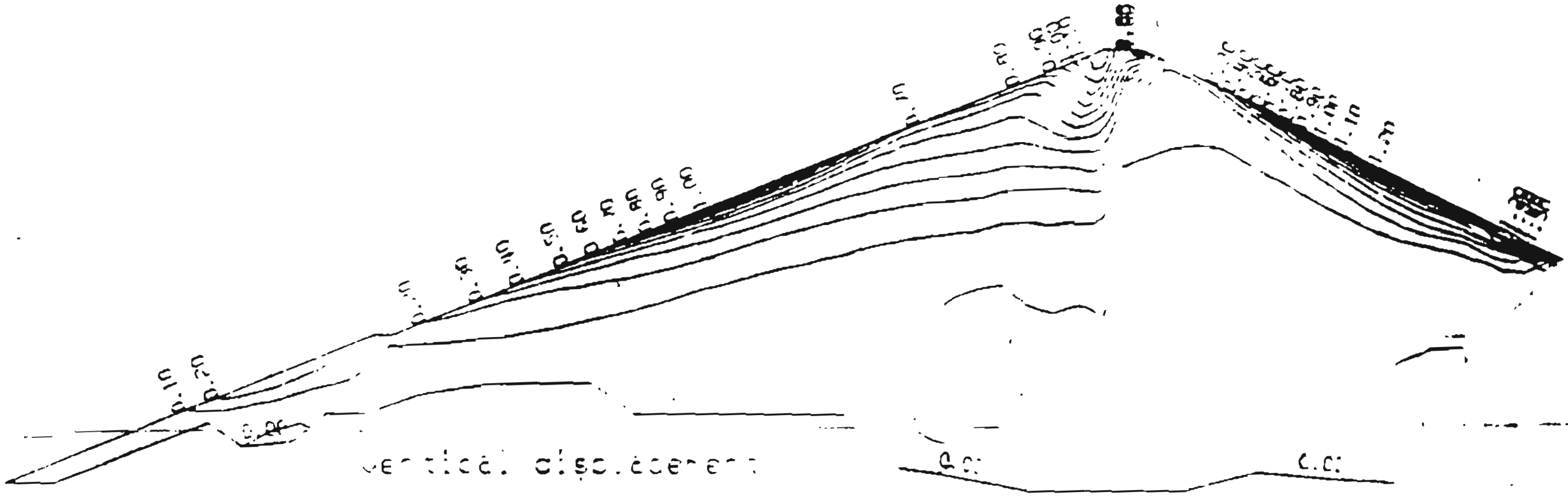


Fig.12 Countours of vertical displacement at the end of earthquake
(section b-11, Khattri earthquake)

Simulated earthquake generated by Professor Khattri, N-S component
Acceleration in m/s2, sampled at 0.02 sec, total ordinates 6496
peak ground acceleration (PGA) value = 10.00999 m/s2

0.000E+01	0.578E-05	0.125E-04	0.187E-04	0.234E-04	0.318E-04	0.394E-04
0.462E-04	0.421E-04	0.274E-04	0.169E-04	0.241E-04	0.409E-04	0.502E-04
0.338E-04	0.883E-05	0.113E-04	0.493E-04	0.932E-04	0.114E-03	0.117E-03
0.120E-03	0.122E-03	0.120E-03	0.123E-03	0.140E-03	0.160E-03	0.174E-03
0.150E-03	0.100E-03	0.738E-04	0.838E-04	0.110E-03	0.112E-03	0.896E-04
0.994E-04	0.137E-03	0.164E-03	0.158E-03	0.115E-03	0.786E-04	0.738E-04
0.713E-04	0.516E-04	0.302E-04	0.599E-04	0.118E-03	0.151E-03	0.128E-03
0.102E-03	0.137E-03	0.230E-03	0.296E-03	0.278E-03	0.223E-03	0.209E-03
0.265E-03	0.344E-03	0.403E-03	0.398E-03	0.356E-03	0.325E-03	0.292E-03
0.265E-03	0.235E-03	0.235E-03	0.297E-03	0.374E-03	0.410E-03	0.353E-03
0.256E-03	0.254E-03	0.353E-03	0.454E-03	0.445E-03	0.370E-03	0.371E-03
0.549E-03	0.742E-03	0.827E-03	0.749E-03	0.640E-03	0.618E-03	0.641E-03
0.583E-03	0.430E-03	0.306E-03	0.325E-03	0.465E-03	0.553E-03	0.542E-03
0.502E-03	0.551E-03	0.670E-03	0.737E-03	0.667E-03	0.518E-03	0.448E-03
0.478E-03	0.488E-03	0.396E-03	0.289E-03	0.266E-03	0.364E-03	0.469E-03
0.450E-03	0.338E-03	0.240E-03	0.222E-03	0.253E-03	0.269E-03	0.301E-03
0.419E-03	0.562E-03	0.557E-03	0.366E-03	0.180E-03	0.189E-03	0.363E-03
0.487E-03	0.440E-03	0.330E-03	0.327E-03	0.403E-03	0.387E-03	0.123E-03
-0.923E-05	-0.437E-04	-0.195E-04	-0.126E-05	-0.217E-03	-0.394E-03	-0.446E-03
-0.337E-03	-0.242E-03	-0.399E-03	-0.684E-03	-0.753E-03	-0.629E-03	-0.542E-03
-0.859E-03	-0.159E-02	-0.212E-02	-0.292E-02	-0.382E-02	-0.385E-02	-0.351E-02
-0.343E-02	-0.377E-02	-0.391E-02	-0.360E-02	-0.313E-02	-0.299E-02	-0.342E-02
-0.357E-02	-0.294E-02	-0.217E-02	-0.212E-02	-0.290E-02	-0.368E-02	-0.405E-02
-0.393E-02	-0.438E-02	-0.524E-02	-0.514E-02	-0.382E-02	-0.260E-02	-0.317E-02
-0.454E-02	-0.527E-02	-0.430E-02	-0.292E-02	-0.291E-02	-0.384E-02	-0.381E-02
-0.233E-02	-0.137E-02	-0.229E-02	-0.371E-02	-0.426E-02	-0.334E-02	-0.234E-02
-0.246E-02	-0.359E-02	-0.399E-02	-0.292E-02	-0.160E-02	-0.153E-02	-0.219E-02
-0.210E-02	-0.114E-02	-0.810E-03	-0.221E-02	-0.435E-02	-0.536E-02	-0.426E-02
-0.228E-02	-0.182E-02	-0.314E-02	-0.411E-02	-0.308E-02	-0.122E-02	-0.748E-03
-0.197E-02	-0.253E-02	-0.137E-02	0.206E-03	0.182E-03	-0.164E-02	-0.261E-02
0.229E-02	0.492E-03	0.305E-03	-0.173E-02	-0.325E-02	-0.269E-02	-0.140E-02
-0.202E-02	-0.429E-02	-0.496E-02	-0.273E-02	0.708E-04	0.329E-03	-0.142E-02
-0.198E-02	-0.141E-03	0.154E-02	0.597E-03	-0.191E-02	-0.260E-02	-0.436E-03
0.199E-02	0.140E-02	-0.998E-03	-0.867E-03	0.319E-02	0.729E-02	0.740E-02
0.490E-02	0.397E-02	0.643E-02	0.931E-02	0.905E-02	0.661E-02	0.576E-02
0.784E-02	0.977E-02	0.849E-02	0.568E-02	0.576E-02	0.899E-02	0.115E-01
0.102E-01	0.687E-02	0.651E-02	0.100E-01	0.132E-01	0.117E-01	0.720E-02
0.491E-02	0.663E-02	0.829E-02	0.612E-02	0.157E-02	-0.639E-03	0.606E-03
0.873E-03	-0.341E-02	-0.100E-01	-0.130E-01	-0.106E-01	-0.687E-02	-0.677E-02
-0.842E-02	-0.665E-02	-0.158E-03	0.607E-02	0.751E-02	0.513E-02	0.400E-02
0.610E-02	0.742E-02	0.483E-02	0.212E-03	-0.132E-02	0.149E-02	0.529E-02
0.641E-02	0.709E-02	0.130E-01	0.246E-01	0.354E-01	0.398E-01	0.393E-01
0.390E-01	0.401E-01	0.378E-01	0.284E-01	0.149E-01	0.396E-02	0.117E-03
-0.633E-03	-0.880E-03	0.133E-02	0.700E-02	0.138E-01	0.158E-01	0.124E-01
0.825E-02	0.902E-02	0.136E-01	0.146E-01	0.797E-02	-0.321E-02	-0.138E-01
-0.227E-01	-0.331E-01	-0.448E-01	-0.520E-01	-0.498E-01	-0.420E-01	-0.353E-01
-0.325E-01	-0.275E-01	-0.172E-01	-0.593E-02	-0.443E-02	-0.159E-01	-0.319E-01
-0.408E-01	-0.403E-01	-0.360E-01	-0.325E-01	-0.249E-01	-0.101E-01	0.569E-02
0.835E-02	-0.101E-01	-0.438E-01	-0.788E-01	-0.105E+00	-0.124E+00	-0.133E+00
-0.130E+00	-0.109E+00	-0.732E-01	-0.356E-01	-0.599E-02	0.146E-01	0.292E-01
0.364E-01	0.290E-01	0.506E-02	-0.270E-01	-0.528E-01	-0.647E-01	-0.623E-01
-0.501E-01	-0.292E-01	-0.408E-02	0.175E-01	0.271E-01	0.232E-01	0.134E-01
0.719E-02	0.483E-02	0.215E-03	-0.923E-02	-0.185E-01	-0.225E-01	-0.244E-01
-0.316E-01	-0.472E-01	-0.627E-01	-0.681E-01	-0.618E-01	-0.509E-01	-0.407E-01

-0.296E 01	-0.121E-01	0.867E-02	0.242E-01	0.292E-01	0.306E-01	0.355E-01
0.425E-01	0.438E-01	0.368E-01	0.279E-01	0.251E-01	0.266E-01	0.245E-01
0.158E-01	0.834E-02	0.107E-01	0.207E-01	0.293E-01	0.316E-01	0.326E-01
0.375E-01	0.412E-01	0.344E-01	0.154E-01	-0.361E-02	-0.107E-01	-0.655E-02
-0.316E-02	-0.675E-02	-0.118E-01	-0.893E-02	0.788E-03	0.449E-02	-0.983E-02
-0.405E-01	-0.770E-01	-0.109E+00	-0.133E+00	-0.142E+00	-0.127E+00	-0.873E-01
-0.326E-01	0.204E-01	0.598E-01	0.848E-01	0.985E-01	0.101E+00	0.871E-01
0.613E-01	0.368E-01	0.241E-01	0.249E-01	0.331E-01	0.450E-01	0.628E-01
0.800E-01	0.833E-01	0.622E-01	0.206E-01	-0.229E-01	-0.512E-01	-0.617E-01
-0.650E-01	-0.679E-01	-0.663E-01	-0.568E-01	-0.429E-01	-0.365E-01	-0.447E-01
-0.646E-01	-0.919E-01	-0.125E+00	-0.164E+00	-0.198E+00	-0.211E+00	-0.196E+00
-0.161E+00	-0.123E+00	-0.891E-01	-0.508E-01	-0.202E-02	0.481E-01	0.786E-01
0.784E-01	0.537E-01	0.219E-01	-0.803E-02	-0.368E-01	-0.648E-01	-0.877E-01
-0.977E-01	-0.954E-01	-0.862E-01	-0.727E-01	-0.492E-01	-0.145E-01	0.215E-01
0.465E-01	0.556E-01	0.570E-01	0.596E-01	0.585E-01	0.425E-01	0.747E-02
-0.334E-01	-0.673E-01	-0.878E-01	-0.101E+00	-0.107E+00	-0.101E+00	-0.792E-01
-0.510E-01	-0.280E-01	-0.152E-01	-0.526E-02	0.896E-02	0.223E-01	0.252E-01
0.181E-01	0.101E-01	0.101E-01	0.151E-01	0.159E-01	0.119E-01	0.130E-01
0.246E-01	0.388E-01	0.429E-01	0.401E-01	0.428E-01	0.595E-01	0.792E-01
0.872E-01	0.839E-01	0.852E-01	0.995E-01	0.115E+00	0.109E+00	0.783E-01
0.414E-01	0.172E-01	0.443E-02	-0.139E-01	-0.377E-01	-0.500E-01	-0.317E-01
0.475E-02	0.318E-01	0.325E-01	0.196E-01	0.157E-01	0.232E-01	0.233E-01
0.337E-02	-0.273E-01	-0.468E-01	-0.460E-01	-0.354E-01	-0.283E-01	-0.200E-01
-0.260E-02	0.200E-01	0.300E-01	0.161E-01	-0.104E-01	-0.298E-01	-0.297E-01
-0.218E-01	-0.173E-01	-0.174E-01	-0.141E-01	-0.109E-01	-0.122E-01	-0.246E-01
-0.330E-01	-0.329E-01	-0.263E-01	-0.251E-01	-0.324E-01	-0.303E-01	-0.116E-01
0.148E-01	0.201E-01	-0.887E-02	-0.499E-01	-0.735E-01	-0.722E-01	-0.579E-01
-0.499E-01	-0.424E-01	-0.277E-01	-0.735E-02	0.524E-02	0.338E-02	-0.149E-02
0.869E-02	0.290E-01	0.403E-01	0.329E-01	0.186E-01	0.177E-01	0.247E-01
0.181E-01	-0.127E-01	-0.507E-01	-0.615E-01	-0.394E-01	-0.491E-02	0.157E-01
0.231E-01	0.249E-01	0.235E-01	0.651E-02	-0.208E-01	-0.416E-01	-0.359E-01
-0.245E-01	-0.438E-01	-0.102E+00	-0.147E+00	-0.116E+00	-0.733E-02	0.902E-01
0.894E-01	-0.181E-01	-0.150E+00	-0.218E+00	-0.215E+00	-0.207E+00	-0.250E+00
-0.320E+00	-0.352E+00	-0.299E+00	-0.194E+00	-0.117E+00	-0.120E+00	-0.191E+00
-0.276E+00	-0.330E+00	-0.346E+00	-0.339E+00	-0.331E+00	-0.317E+00	-0.277E+00
-0.195E+00	-0.852E-01	0.421E-02	0.185E-01	-0.557E-01	-0.164E+00	-0.221E+00
-0.183E+00	-0.862E-01	-0.256E-01	-0.655E-01	-0.182E+00	-0.279E+00	-0.280E+00
-0.185E+00	-0.713E-01	-0.204E-01	-0.543E-01	-0.133E+00	-0.198E+00	-0.230E+00
-0.249E+00	-0.281E+00	-0.323E+00	-0.336E+00	-0.275E+00	-0.153E+00	-0.311E-01
0.191E-01	-0.296E-01	-0.123E+00	-0.169E+00	-0.969E-01	0.671E-01	0.211E+00
0.208E+00	0.340E-01	-0.204E+00	-0.337E+00	-0.254E+00	-0.865E-02	0.226E+00
0.279E+00	0.136E+00	-0.729E-01	-0.176E+00	-0.119E+00	0.244E-01	0.127E+00
0.145E+00	0.112E+00	0.102E+00	0.127E+00	0.146E+00	0.132E+00	0.922E-01
0.536E-01	0.199E-01	-0.254E-01	-0.932E-01	-0.145E+00	-0.131E+00	-0.449E-01
0.618E-01	0.125E+00	0.111E+00	0.414E-01	-0.514E-01	-0.154E+00	-0.266E+00
-0.367E+00	-0.408E+00	-0.349E+00	-0.212E+00	-0.522E-01	0.471E-01	0.490E-01
-0.194E-01	-0.988E-01	-0.123E+00	-0.719E-01	0.143E-01	0.758E-01	0.617E-01
-0.201E-01	-0.953E-01	-0.876E-01	0.328E-02	0.107E+00	0.112E+00	-0.199E-01
-0.212E+00	-0.342E+00	-0.324E+00	-0.214E+00	-0.126E+00	-0.144E+00	-0.234E+00
-0.276E+00	-0.208E+00	-0.812E-01	-0.278E-01	-0.113E+00	-0.275E+00	-0.378E+00
-0.344E+00	-0.210E+00	-0.825E-01	-0.311E-01	-0.410E-01	-0.644E-01	-0.819E-01
-0.932E-01	-0.789E-01	-0.120E-01	0.951E-01	0.164E+00	0.106E+00	-0.692E-01
-0.246E+00	-0.290E+00	-0.205E+00	-0.910E-01	-0.584E-01	-0.104E+00	-0.128E+00
-0.589E-01	0.684E-01	0.142E+00	0.117E+00	0.108E-01	-0.993E-01	-0.164E+00
-0.155E+00	-0.839E-01	0.283E-01	0.881E-01	0.303E-01	-0.134E+00	-0.264E+00
-0.238E+00	-0.662E-01	0.478E-01	-0.601E-01	-0.328E+00	-0.494E+00	-0.361E+00
-0.184E-01	0.232E+00	0.170E+00	-0.130E+00	-0.377E+00	-0.387E+00	-0.228E+00
-0.116E+00	-0.167E+00	-0.280E+00	-0.298E+00	-0.152E+00	0.163E-01	0.129E+00

-0.191E+00	-0.234E+00	-0.375E+00	-0.492E+00	-0.429E+00	-0.189E+00	0.742E-01
0.173E+00	0.224E-01	-0.239E+00	-0.410E+00	-0.400E+00	-0.244E+00	-0.883E-01
-0.343E-01	-0.718E-01	-0.141E+00	-0.175E+00	-0.161E+00	-0.110E+00	-0.499E-01
-0.783E-02	0.226E-01	0.479E-01	0.107E+00	0.216E+00	0.321E+00	0.343E+00
0.214E+00	-0.322E-01	-0.266E+00	-0.362E+00	-0.310E+00	-0.178E+00	-0.614E-01
0.251E-01	0.991E-01	0.192E+00	0.259E+00	0.275E+00	0.220E+00	0.128E+00
0.428E-01	0.272E-02	-0.134E-02	0.205E-01	0.102E+00	0.195E+00	0.245E+00
0.256E+00	0.141E+00	-0.234E-01	-0.200E+00	-0.328E+00	-0.398E+00	-0.378E+00
-0.326E+00	-0.274E+00	-0.233E+00	-0.267E+00	-0.371E+00	-0.563E+00	-0.828E+00
-0.101E+01	-0.985E+00	-0.666E+00	-0.176E+00	0.261E+00	0.496E+00	0.515E+00
0.424E+00	0.281E+00	0.982E-01	-0.162E+00	-0.418E+00	-0.563E+00	-0.521E+00
-0.354E+00	-0.208E+00	-0.133E+00	-0.101E+00	-0.114E+00	-0.183E+00	-0.373E+00
-0.624E+00	-0.803E+00	-0.763E+00	-0.599E+00	-0.426E+00	-0.407E+00	-0.436E+00
-0.400E+00	-0.267E+00	-0.237E+00	-0.465E+00	-0.100E+01	-0.162E+01	-0.200E+01
-0.139E+01	-0.173E+01	-0.145E+01	-0.138E+01	-0.150E+01	-0.161E+01	-0.151E+01
-0.123E+01	-0.912E+00	-0.808E+00	-0.905E+00	-0.966E+00	-0.743E+00	-0.340E+00
-0.567E-01	-0.279E+00	-0.104E+01	-0.197E+01	-0.271E+01	-0.312E+01	-0.325E+01
-0.324E+01	-0.290E+01	-0.216E+01	-0.117E+01	-0.294E+00	0.118E+00	0.109E+00
0.105E+00	0.400E+00	0.108E+01	0.193E+01	0.282E+01	0.368E+01	0.445E+01
0.492E+01	0.484E+01	0.410E+01	0.286E+01	0.157E+01	0.519E+00	-0.843E-01
-0.234E+00	-0.146E+00	-0.285E-01	-0.117E+00	-0.297E+00	-0.362E+00	0.666E-01
0.107E+01	0.227E+01	0.335E+01	0.403E+01	0.435E+01	0.440E+01	0.408E+01
0.322E+01	0.185E+01	0.374E+00	-0.712E+00	-0.117E+01	-0.130E+01	-0.145E+01
-0.189E+01	-0.249E+01	-0.295E+01	-0.310E+01	-0.290E+01	-0.249E+01	-0.184E+01
-0.109E+01	-0.235E+00	0.580E+00	0.131E+01	0.182E+01	0.199E+01	0.175E+01
0.114E+01	0.287E+00	-0.402E+00	-0.668E+00	-0.449E+00	0.376E+00	0.170E+01
0.339E+01	0.505E+01	0.616E+01	0.619E+01	0.492E+01	0.277E+01	0.257E+00
-0.203E+01	-0.376E+01	-0.492E+01	-0.547E+01	-0.536E+01	-0.458E+01	-0.325E+01
-0.181E+01	-0.702E+00	-0.119E+00	0.131E+00	0.561E+00	0.143E+01	0.283E+01
0.438E+01	0.571E+01	0.661E+01	0.695E+01	0.673E+01	0.560E+01	0.366E+01
0.106E+01	-0.164E+01	-0.373E+01	-0.484E+01	-0.488E+01	-0.414E+01	-0.291E+01
-0.151E+01	-0.214E+00	0.778E+00	0.133E+01	0.135E+01	0.880E+00	0.175E-01
-0.107E+01	-0.203E+01	-0.262E+01	-0.281E+01	-0.276E+01	-0.274E+01	-0.291E+01
-0.306E+01	-0.315E+01	-0.315E+01	-0.321E+01	-0.321E+01	-0.280E+01	-0.163E+01
0.169E+00	0.196E+01	0.293E+01	0.277E+01	0.180E+01	0.518E+00	-0.639E+00
-0.174E+01	-0.255E+01	-0.290E+01	-0.239E+01	-0.104E+01	0.768E+00	0.244E+01
0.355E+01	0.425E+01	0.464E+01	0.498E+01	0.511E+01	0.501E+01	0.450E+01
0.362E+01	0.218E+01	0.456E+00	-0.148E+01	-0.315E+01	-0.419E+01	-0.464E+01
-0.449E+01	-0.404E+01	-0.332E+01	-0.253E+01	-0.192E+01	-0.178E+01	-0.198E+01
-0.216E+01	-0.193E+01	-0.111E+01	0.923E-01	0.131E+01	0.249E+01	0.352E+01
0.414E+01	0.390E+01	0.265E+01	0.855E+00	-0.525E+00	-0.709E+00	0.196E+00
0.173E+01	0.343E+01	0.523E+01	0.728E+01	0.914E+01	0.100E+02	0.922E+01
0.726E+01	0.511E+01	0.364E+01	0.286E+01	0.210E+01	0.949E+00	-0.311E+00
-0.108E+01	-0.123E+01	-0.129E+01	-0.175E+01	-0.253E+01	-0.309E+01	-0.291E+01
-0.204E+01	-0.101E+01	-0.140E+00	0.642E+00	0.148E+01	0.222E+01	0.246E+01
0.187E+01	0.780E+00	-0.406E+00	-0.106E+01	-0.123E+01	-0.876E+00	-0.220E+00
0.721E+00	0.164E+01	0.215E+01	0.199E+01	0.115E+01	0.212E+00	-0.470E+00
-0.659E+00	-0.397E+00	0.556E-01	0.583E+00	0.983E+00	0.113E+01	0.862E+00
0.137E+00	-0.665E+00	-0.124E+01	-0.124E+01	-0.706E+00	0.117E+00	0.111E+01
0.199E+01	0.285E+01	0.354E+01	0.393E+01	0.389E+01	0.340E+01	0.258E+01
0.164E+01	0.702E+00	-0.306E+00	-0.139E+01	-0.249E+01	-0.330E+01	-0.368E+01
-0.350E+01	-0.294E+01	-0.219E+01	-0.132E+01	-0.165E+00	0.113E+01	0.237E+01
0.335E+01	0.382E+01	0.396E+01	0.375E+01	0.322E+01	0.230E+01	0.105E+01
-0.310E+00	-0.147E+01	-0.231E+01	-0.293E+01	-0.345E+01	-0.382E+01	-0.383E+01
-0.345E+01	-0.273E+01	-0.203E+01	-0.135E+01	-0.526E+00	0.428E+00	0.155E+01
0.242E+01	0.278E+01	0.255E+01	0.196E+01	0.107E+01	-0.506E+01	-0.126E+01
-0.262E+01	-0.369E+01	-0.444E+01	-0.481E+01	-0.504E+01	-0.527E+01	-0.538E+01
-0.502E+01	-0.405E+01	-0.264E+01	-0.130E+01	-0.382E+00	-0.427E+02	0.113E+00
0.171E+00	0.158E+00	-0.766E-01	-0.382E+00	-0.390E+00	0.418E+00	0.191E+01
0.371E+01	0.495E+01	0.545E+01	0.537E+01	0.536E+01	0.569E+01	0.609E+01

0.625E+01	0.605E+01	0.563E+01	0.523E+01	0.487E+01	0.429E+01	0.322E+01
0.180E+01	0.273E+00	-0.746E+00	-0.129E+01	-0.136E+01	-0.134E+01	-0.139E+01
-0.140E+01	-0.116E+01	-0.584E+00	0.266E+00	0.956E+00	0.123E+01	0.108E+01
0.750E+00	0.438E+00	0.201E+00	-0.117E+00	-0.538E+00	-0.923E+00	-0.121E+01
-0.119E+01	-0.116E+01	-0.118E+01	-0.145E+01	-0.174E+01	-0.181E+01	-0.157E+01
-0.101E+01	-0.401E+00	0.488E-01	0.173E+00	-0.475E-01	-0.487E+00	-0.106E+01
-0.164E+01	-0.211E+01	-0.250E+01	-0.275E+01	-0.278E+01	-0.266E+01	-0.238E+01
-0.213E+01	-0.194E+01	-0.175E+01	-0.141E+01	-0.863E+00	-0.188E+00	0.394E+00
0.780E+00	0.997E+00	0.124E+01	0.154E+01	0.185E+01	0.197E+01	0.183E+01
0.146E+01	0.104E+01	0.768E+00	0.644E+00	0.583E+00	0.616E+00	0.597E+00
0.536E+00	0.252E+00	-0.221E+00	-0.765E+00	-0.122E+01	-0.132E+01	-0.122E+01
-0.107E+01	-0.107E+01	-0.134E+01	-0.167E+01	-0.197E+01	-0.227E+01	-0.265E+01
-0.312E+01	-0.348E+01	-0.366E+01	-0.353E+01	-0.327E+01	-0.299E+01	-0.288E+01
-0.283E+01	-0.285E+01	-0.285E+01	-0.266E+01	-0.209E+01	-0.104E+01	0.351E+00
0.173E+01	0.278E+01	0.332E+01	0.337E+01	0.311E+01	0.250E+01	0.160E+01
0.549E+00	-0.408E+00	-0.885E+00	-0.864E+00	-0.442E+00	0.585E-01	0.467E+00
0.612E+00	0.443E+00	0.102E+00	-0.349E+00	-0.704E+00	-0.892E+00	-0.101E+01
-0.129E+01	-0.167E+01	-0.194E+01	-0.194E+01	-0.157E+01	-0.111E+01	-0.883E+00
-0.859E+00	-0.799E+00	-0.395E+00	0.365E+00	0.129E+01	0.212E+01	0.265E+01
0.300E+01	0.321E+01	0.335E+01	0.330E+01	0.296E+01	0.241E+01	0.174E+01
0.100E+01	0.321E+00	-0.349E+00	-0.911E+00	-0.146E+01	-0.191E+01	-0.220E+01
-0.229E+01	-0.207E+01	-0.164E+01	-0.118E+01	-0.908E+00	-0.903E+00	-0.108E+01
-0.111E+01	-0.811E+00	-0.221E+00	0.422E+00	0.868E+00	0.109E+01	0.114E+01
0.111E+01	0.808E+00	0.168E+00	-0.790E+00	-0.169E+01	-0.235E+01	-0.270E+01
-0.306E+01	-0.354E+01	-0.416E+01	-0.457E+01	-0.468E+01	-0.454E+01	-0.434E+01
-0.401E+01	-0.342E+01	-0.240E+01	-0.124E+01	-0.304E+00	0.118E+00	0.167E+00
0.215E+00	0.453E+00	0.811E+00	0.108E+01	0.119E+01	0.126E+01	0.147E+01
0.176E+01	0.199E+01	0.192E+01	0.155E+01	0.942E+00	0.305E+00	-0.191E+00
-0.428E+00	-0.428E+00	-0.258E+00	0.114E-01	0.371E+00	0.894E+00	0.152E+01
0.208E+01	0.230E+01	0.201E+01	0.130E+01	0.368E+00	-0.596E+00	-0.152E+01
-0.238E+01	-0.309E+01	-0.351E+01	-0.351E+01	-0.318E+01	-0.264E+01	-0.201E+01
-0.134E+01	-0.673E+00	-0.386E-01	0.596E+00	0.124E+01	0.194E+01	0.255E+01
0.298E+01	0.313E+01	0.304E+01	0.287E+01	0.267E+01	0.235E+01	0.181E+01
0.115E+01	0.518E+00	0.126E+00	-0.424E-01	-0.155E+00	-0.362E+00	-0.657E+00
-0.955E+00	-0.116E+01	-0.123E+01	-0.116E+01	-0.932E+00	-0.622E+00	-0.333E+00
-0.118E+00	-0.555E-02	0.400E-01	0.594E-01	0.297E-01	-0.143E-02	-0.439E-01
-0.386E-01	0.622E-01	0.210E+00	0.341E+00	0.529E+00	0.758E+00	0.110E+01
0.147E+01	0.179E+01	0.200E+01	0.215E+01	0.214E+01	0.201E+01	0.166E+01
0.120E+01	0.715E+00	0.427E+00	0.254E+00	0.238E+00	0.169E+00	0.549E-01
-0.140E+00	-0.411E+00	-0.780E+00	-0.120E+01	-0.160E+01	-0.193E+01	-0.214E+01
-0.220E+01	-0.211E+01	-0.185E+01	-0.146E+01	-0.105E+01	-0.773E+00	-0.679E+00
-0.772E+00	-0.930E+00	-0.110E+01	-0.127E+01	-0.141E+01	-0.156E+01	-0.167E+01
-0.172E+01	-0.171E+01	-0.161E+01	-0.147E+01	-0.136E+01	-0.129E+01	-0.123E+01
-0.110E+01	-0.800E+00	-0.423E+00	-0.588E-01	0.156E+00	0.277E+00	0.322E+00
0.348E+00	0.312E+00	0.203E+00	0.385E-01	-0.123E+00	-0.212E+00	-0.251E+00
-0.226E+00	-0.806E-01	0.271E+00	0.902E+00	0.171E+01	0.254E+01	0.317E+01
0.348E+01	0.334E+01	0.281E+01	0.204E+01	0.122E+01	0.524E+00	0.247E-01
-0.344E+00	-0.578E+00	-0.774E+00	-0.850E+00	-0.859E+00	-0.798E+00	-0.699E+00
-0.522E+00	-0.247E+00	0.120E+00	0.490E+00	0.866E+00	0.119E+01	0.142E+01
0.144E+01	0.116E+01	0.638E+00	0.123E+00	-0.114E+00	-0.371E-01	0.216E+00
0.434E+00	0.532E+00	0.602E+00	0.695E+00	0.803E+00	0.881E+00	0.896E+00
0.978E+00	0.109E+01	0.118E+01	0.114E+01	0.996E+00	0.879E+00	0.940E+00
0.104E+01	0.108E+01	0.874E+00	0.552E+00	0.209E+00	-0.850E-01	-0.419E+00
-0.806E+00	-0.114E+01	-0.128E+01	-0.112E+01	-0.726E+00	-0.282E+00	0.709E-01
0.229E+00	0.187E+00	0.114E-01	-0.216E+00	-0.330E+00	-0.300E+00	-0.150E+00
-0.234E-01	-0.532E-01	-0.217E+00	-0.415E+00	-0.578E+00	-0.715E+00	-0.895E+00
-0.110E+01	-0.125E+01	-0.120E+01	-0.957E+00	-0.657E+00	-0.464E+00	-0.482E+00
-0.632E+00	-0.741E+00	-0.687E+00	-0.481E+00	-0.264E+00	-0.999E-01	0.586E-01
0.266E+00	0.524E+00	0.690E+00	0.592E+00	0.255E+00	-0.867E-01	-0.257E+00
-0.174E+00	-0.668E-01	-0.166E+00	-0.377E+00	-0.582E+00	-0.577E+00	-0.501E+00

-0.484E+00	-0 650E+00	-0.837E+00	-0.851E+00	-0.607E+00	-0.175E+00	0.295E+00
0.728E+00	0.115E+01	0.155E+01	0.193E+01	0.216E+01	0.220E+01	0.202E+01
0.165E+01	0.118E+01	0.836E+00	0.663E+00	0.699E+00	0.742E+00	0.633E+00
0.356E+00	0.395E-01	-0.107E+00	-0.470E-01	0.797E-01	0.196E+00	0.196E+00
0.124E+00	-0.679E-02	-0.206E+00	-0.460E+00	-0.716E+00	-0.920E+00	-0.954E+00
-0.863E+00	-0.604E+00	-0.316E+00	-0.128E+00	-0.172E+00	-0.394E+00	-0.595E+00
-0.434E+00	0.109E+00	0.734E+00	0.110E+01	0.968E+00	0.620E+00	0.396E+00
0.473E+00	0.702E+00	0.926E+00	0.109E+01	0.139E+01	0.194E+01	0.251E+01
0.279E+01	0.253E+01	0.191E+01	0.125E+01	0.834E+00	0.594E+00	0.417E+00
0.119E+00	-0.134E+00	-0.324E+00	-0.337E+00	-0.399E+00	-0.620E+00	-0.104E+01
-0.153E+01	-0.183E+01	-0.191E+01	-0.175E+01	-0.154E+01	-0.134E+01	-0.117E+01
-0.100E+01	-0.769E+00	-0.617E+00	-0.518E+00	-0.570E+00	-0.651E+00	-0.775E+00
-0.853E+00	-0.854E+00	-0.769E+00	-0.588E+00	-0.375E+00	-0.332E+00	-0.467E+00
-0.753E+00	-0.102E+01	-0.119E+01	-0.127E+01	-0.143E+01	-0.170E+01	-0.193E+01
-0.199E+01	-0.179E+01	-0.148E+01	-0.115E+01	-0.862E+00	-0.574E+00	-0.271E+00
-0.623E-01	-0.443E-01	-0.178E+00	-0.313E+00	-0.284E+00	-0.854E-01	0.138E+00
0.200E+00	0.340E-01	-0.227E+00	-0.441E+00	-0.490E+00	-0.359E+00	-0.105E+00
0.258E+00	0.693E+00	0.113E+01	0.144E+01	0.150E+01	0.129E+01	0.971E+00
0.788E+00	0.806E+00	0.981E+00	0.110E+01	0.104E+01	0.829E+00	0.615E+00
0.461E+00	0.287E+00	-0.341E-01	-0.441E+00	-0.777E+00	-0.859E+00	-0.731E+00
-0.649E+00	-0.804E+00	-0.122E+01	-0.163E+01	-0.182E+01	-0.154E+01	-0.939E+00
-0.232E+00	0.236E+00	0.316E+00	0.932E-01	-0.722E-01	0.184E+00	0.794E+00
0.146E+01	0.177E+01	0.160E+01	0.118E+01	0.908E+00	0.826E+00	0.758E+00
0.490E+00	0.317E-01	-0.324E+00	-0.389E+00	-0.202E+00	-0.314E-01	-0.203E-01
-0.840E-01	-0.752E-01	0.602E-01	0.267E+00	0.332E+00	0.266E+00	0.171E+00
0.840E-01	0.127E+00	0.250E+00	0.438E+00	0.646E+00	0.777E+00	0.767E+00
0.577E+00	0.235E+00	-0.262E+00	-0.809E+00	-0.131E+01	-0.162E+01	-0.167E+01
-0.156E+01	-0.153E+01	-0.172E+01	-0.191E+01	-0.180E+01	-0.116E+01	-0.190E+00
0.652E+00	0.978E+00	0.869E+00	0.637E+00	0.629E+00	0.827E+00	0.112E+01
0.138E+01	0.171E+01	0.216E+01	0.255E+01	0.264E+01	0.223E+01	0.146E+01
0.712E+00	0.263E+00	0.139E+00	0.136E+00	-0.248E-01	-0.404E+00	-0.936E+00
-0 141E+01	-0.168E+01	-0.175E+01	-0.163E+01	-0.154E+01	-0.146E+01	-0.135E+01
-0.112E+01	-0.710E+00	-0.213E+00	0.245E+00	0.479E+00	0.506E+00	0.329E+00
0.112E+00	-0 153E+00	-0.373E+00	-0.545E+00	-0.663E+00	-0.680E+00	-0.521E+00
-0.255E+00	0.738E-01	0.289E+00	0.239E+00	-0.482E-01	-0.415E+00	-0.572E+00
-0.451E+00	-0.157E+00	0.678E-01	0.128E+00	0.192E+00	0.379E+00	0.728E+00
0.100E+01	0.973E+00	0.662E+00	0.318E+00	0.212E+00	0.318E+00	0.475E+00
0.455E+00	0.310E+00	0.278E+00	0.480E+00	0.903E+00	0.124E+01	0.132E+01
0.110E+01	0.875E+00	0.891E+00	0.122E+01	0.169E+01	0.210E+01	0.233E+01
0.239E+01	0.240E+01	0.243E+01	0.239E+01	0.219E+01	0.180E+01	0.129E+01
0.830E+00	0.524E+00	0.403E+00	0.475E+00	0.615E+00	0.849E+00	0.102E+01
0.103E+01	0.776E+00	0.209E+00	-0.441E+00	-0.107E+01	-0.152E+01	-0.180E+01
-0.207E+01	-0.235E+01	-0.257E+01	-0.269E+01	-0.252E+01	-0.218E+01	-0.188E+01
-0.170E+01	-0.171E+01	-0.170E+01	-0.145E+01	-0.914E+00	-0.295E+00	0.173E+00
0.337E+00	0.304E+00	0.191E+00	0.215E-01	-0.209E+00	-0.430E+00	-0.422E+00
-0.567E-01	0.591E+00	0.109E+01	0.100E+01	0.391E+00	-0.354E+00	-0.784E+00
-0.851E+00	-0.896E+00	-0.116E+01	-0.156E+01	-0.192E+01	-0.198E+01	-0.187E+01
-0.180E+01	-0.172E+01	-0.149E+01	-0.909E+00	-0.195E+00	0.344E+00	0.481E+00
0.366E+00	0.273E+00	0.325E+00	0.372E+00	0.208E+00	-0.241E+00	-0.699E+00
-0.947E+00	-0.920E+00	-0.756E+00	-0.567E+00	-0.322E+00	0.497E-01	0.592E+00
0.116E+01	0.154E+01	0.152E+01	0.112E+01	0.624E+00	0.214E+00	0.734E-01
0.531E-01	-0.112E+00	-0.381E+00	-0.620E+00	-0.597E+00	-0.290E+00	0.361E-02
0.257E-01	-0.297E+00	-0.615E+00	-0.668E+00	-0.442E+00	-0.238E+00	-0.288E+00
-0.540E+00	-0.757E+00	-0.773E+00	-0.634E+00	-0.659E+00	-0.866E+00	-0.112E+01
-0.110E+01	-0.672E+00	0.400E-01	0.760E+00	0.124E+01	0.130E+01	0.100E+01
0.533E+00	0.680E-01	-0.297E+00	-0.430E+00	-0.444E+00	-0.401E+00	-0.224E+00
0.463E-01	0.417E+00	0.643E+00	0.673E+00	0.468E+00	0.259E+00	0.165E+00
0.214E+00	0.249E+00	0.172E+00	-0.855E-01	-0.422E+00	-0.674E+00	-0.822E+00
-0.797E+00	-0.736E+00	-0.856E+00	-0.124E+01	-0.170E+01	-0.198E+01	-0.182E+01
-0.139E+01	-0.101E+01	-0.923E+00	-0.101E+01	-0.976E+00	-0.552E+00	-0.106E-02

0.321E+00	0.279E+00	0.122E+00	0.245E+00	0.703E+00	0.126E+01	0.159E+01
0.175E+01	0.211E+01	0.278E+01	0.345E+01	0.362E+01	0.300E+01	0.186E+01
0.836E+00	0.206E+00	-0.733E-01	-0.290E+00	-0.543E+00	-0.599E+00	-0.215E+00
0.531E+00	0.128E+01	0.169E+01	0.180E+01	0.182E+01	0.189E+01	0.200E+01
0.179E+01	0.118E+01	0.331E+00	-0.560E+00	-0.136E+01	-0.216E+01	-0.288E+01
-0.347E+01	-0.361E+01	-0.336E+01	-0.280E+01	-0.230E+01	-0.186E+01	-0.134E+01
-0.622E+00	0.129E+00	0.681E+00	0.890E+00	0.823E+00	0.791E+00	0.678E+00
0.329E+00	-0.361E+00	-0.137E+01	-0.228E+01	-0.273E+01	-0.280E+01	-0.251E+01
-0.213E+01	-0.159E+01	-0.106E+01	-0.615E+00	-0.429E+00	-0.326E+00	-0.125E-01
0.633E+00	0.145E+01	0.204E+01	0.223E+01	0.220E+01	0.218E+01	0.235E+01
0.253E+01	0.261E+01	0.266E+01	0.310E+01	0.390E+01	0.486E+01	0.555E+01
0.558E+01	0.519E+01	0.468E+01	0.412E+01	0.355E+01	0.276E+01	0.175E+01
0.734E+00	-0.151E+00	-0.821E+00	-0.127E+01	-0.153E+01	-0.170E+01	-0.175E+01
-0.180E+01	-0.171E+01	-0.138E+01	-0.102E+01	-0.629E+00	-0.619E+00	-0.938E+00
-0.139E+01	-0.164E+01	-0.159E+01	-0.137E+01	-0.134E+01	-0.156E+01	-0.204E+01
-0.246E+01	-0.269E+01	-0.257E+01	-0.229E+01	-0.192E+01	-0.160E+01	-0.134E+01
-0.106E+01	-0.721E+00	-0.284E+00	-0.131E-01	0.567E-01	-0.148E+00	-0.305E+00
-0.144E+00	0.337E+00	0.102E+01	0.165E+01	0.224E+01	0.292E+01	0.367E+01
0.428E+01	0.443E+01	0.413E+01	0.350E+01	0.295E+01	0.261E+01	0.235E+01
0.210E+01	0.170E+01	0.137E+01	0.103E+01	0.639E+00	0.524E-01	-0.613E+00
-0.119E+01	-0.154E+01	-0.150E+01	-0.137E+01	-0.114E+01	-0.900E+00	-0.712E+00
-0.538E+00	-0.532E+00	-0.594E+00	-0.607E+00	-0.375E+00	-0.276E-01	0.357E+00
0.497E+00	0.314E+00	-0.585E-01	-0.493E+00	-0.885E+00	-0.102E+01	-0.918E+00
-0.586E+00	-0.207E+00	0.241E-02	0.147E-01	-0.121E+00	-0.126E+00	0.128E+00
0.546E+00	0.924E+00	0.104E+01	0.887E+00	0.536E+00	0.190E+00	-0.424E-01
-0.175E-01	0.224E+00	0.657E+00	0.113E+01	0.153E+01	0.175E+01	0.175E+01
0.148E+01	0.111E+01	0.714E+00	0.399E+00	0.176E+00	0.540E-02	-0.145E+00
-0.236E+00	-0.282E+00	-0.242E+00	-0.218E+00	-0.308E+00	-0.396E+00	-0.416E+00
-0.233E+00	0.169E+00	0.714E+00	0.130E+01	0.185E+01	0.229E+01	0.250E+01
0.247E+01	0.217E+01	0.182E+01	0.144E+01	0.112E+01	0.691E+00	0.337E+00
0.497E-01	-0.298E-01	0.531E-01	0.222E+00	0.417E+00	0.523E+00	0.551E+00
0.307E+00	-0.196E+00	-0.802E+00	-0.121E+01	-0.122E+01	-0.940E+00	-0.663E+00
-0.438E+00	-0.247E+00	0.130E+00	0.482E+00	0.559E+00	0.107E+00	-0.603E+00
-0.969E+00	-0.880E+00	-0.431E+00	-0.135E+00	-0.123E+00	-0.261E+00	-0.261E+00
-0.121E+00	-0.112E+00	-0.468E+00	-0.964E+00	-0.134E+01	-0.135E+01	-0.115E+01
-0.983E+00	-0.947E+00	-0.957E+00	-0.877E+00	-0.899E+00	-0.100E+01	-0.121E+01
-0.129E+01	-0.113E+01	-0.791E+00	-0.410E+00	-0.159E+00	-0.138E-01	0.616E-01
0.663E-01	0.793E-01	0.880E-01	0.196E+00	0.425E+00	0.692E+00	0.857E+00
0.941E+00	0.978E+00	0.107E+01	0.114E+01	0.107E+01	0.843E+00	0.460E+00
0.725E-01	-0.254E+00	-0.557E+00	-0.751E+00	-0.825E+00	-0.729E+00	-0.467E+00
-0.213E+00	-0.822E-01	-0.140E+00	-0.466E+00	-0.959E+00	-0.153E+01	-0.195E+01
-0.206E+01	-0.183E+01	-0.140E+01	-0.901E+00	-0.444E+00	0.648E-02	0.382E+00
0.649E+00	0.803E+00	0.811E+00	0.803E+00	0.813E+00	0.733E+00	0.483E+00
0.747E-01	-0.315E+00	-0.552E+00	-0.605E+00	-0.570E+00	-0.626E+00	-0.739E+00
-0.912E+00	-0.101E+01	-0.101E+01	-0.916E+00	-0.666E+00	-0.238E+00	0.261E+00
0.724E+00	0.973E+00	0.101E+01	0.917E+00	0.770E+00	0.664E+00	0.567E+00
0.442E+00	0.277E+00	0.834E-01	-0.122E+00	-0.319E+00	-0.428E+00	-0.422E+00
-0.341E+00	-0.172E+00	-0.580E-01	0.126E-02	-0.788E-01	-0.222E+00	-0.427E+00
-0.723E+00	-0.105E+01	-0.143E+01	-0.170E+01	-0.177E+01	-0.154E+01	-0.105E+01
-0.544E+00	-0.541E-01	0.390E+00	0.874E+00	0.131E+01	0.153E+01	0.145E+01
0.114E+01	0.840E+00	0.710E+00	0.665E+00	0.385E+00	-0.287E+00	-0.110E+01
-0.170E+01	-0.177E+01	-0.143E+01	-0.952E+00	-0.499E+00	-0.126E+00	0.278E+00
0.655E+00	0.903E+00	0.969E+00	0.939E+00	0.104E+01	0.130E+01	0.161E+01
0.185E+01	0.184E+01	0.151E+01	0.934E+00	0.133E+00	-0.589E+00	-0.100E+01
-0.938E+00	-0.449E+00	0.584E-01	0.421E+00	0.525E+00	0.508E+00	0.465E+00
0.465E+00	0.396E+00	0.376E+00	0.425E+00	0.540E+00	0.693E+00	0.772E+00
0.812E+00	0.829E+00	0.813E+00	0.799E+00	0.738E+00	0.711E+00	0.754E+00
0.810E+00	0.744E+00	0.522E+00	0.226E+00	-0.286E-02	-0.979E-01	-0.165E+00
-0.304E+00	-0.410E+00	-0.216E+00	0.398E+00	0.137E+01	0.223E+01	0.259E+01
0.241E+01	0.183E+01	0.117E+01	0.472E+00	-0.235E+00	-0.980E+00	-0.158E+01

-0.188E+01	-0.189E+01	-0.177E+01	-0.179E+01	-0.208E+01	-0.246E+01	-0.273E+01
-0.258E+01	-0.205E+01	-0.135E+01	-0.727E+00	-0.320E+00	-0.839E-01	0.161E+00
0.549E+00	0.100E+01	0.128E+01	0.126E+01	0.877E+00	0.345E+00	-0.198E+00
-0.721E+00	-0.128E+01	-0.190E+01	-0.247E+01	-0.271E+01	-0.260E+01	-0.222E+01
-0.191E+01	-0.189E+01	-0.209E+01	-0.235E+01	-0.242E+01	-0.237E+01	-0.229E+01
-0.229E+01	-0.227E+01	-0.211E+01	-0.173E+01	-0.120E+01	-0.644E+00	-0.261E+00
-0.280E-01	-0.210E-01	-0.128E+00	-0.281E+00	-0.310E+00	-0.121E+00	0.305E+00
0.750E+00	0.112E+01	0.142E+01	0.172E+01	0.208E+01	0.241E+01	0.254E+01
0.244E+01	0.223E+01	0.208E+01	0.185E+01	0.134E+01	0.433E+00	-0.674E+00
-0.157E+01	-0.189E+01	-0.168E+01	-0.120E+01	-0.776E+00	-0.489E+00	-0.291E+00
-0.607E-01	0.165E+00	0.259E+00	0.237E+00	0.150E+00	0.197E+00	0.401E+00
0.730E+00	0.104E+01	0.111E+01	0.876E+00	0.391E+00	-0.233E+00	-0.684E+00
-0.820E+00	-0.672E+00	-0.345E+00	-0.321E-01	0.240E+00	0.458E+00	0.639E+00
0.744E+00	0.716E+00	0.586E+00	0.437E+00	0.391E+00	0.490E+00	0.606E+00
0.661E+00	0.606E+00	0.488E+00	0.363E+00	0.262E+00	0.209E+00	0.179E+00
0.211E+00	0.183E+00	0.142E+00	0.709E-01	0.706E-01	0.219E+00	0.436E+00
0.514E+00	0.341E+00	-0.977E-01	-0.574E+00	-0.861E+00	-0.880E+00	-0.762E+00
-0.594E+00	-0.410E+00	-0.143E+00	0.187E+00	0.460E+00	0.477E+00	0.923E-01
-0.524E+00	-0.110E+01	-0.134E+01	-0.118E+01	-0.785E+00	-0.422E+00	-0.180E+00
-0.220E-01	0.124E+00	0.267E+00	0.279E+00	0.116E+00	-0.178E+00	-0.405E+00
-0.407E+00	-0.321E+00	-0.281E+00	-0.475E+00	-0.731E+00	-0.846E+00	-0.771E+00
-0.618E+00	-0.643E+00	-0.977E+00	-0.137E+01	-0.157E+01	-0.152E+01	-0.136E+01
-0.135E+01	-0.155E+01	-0.193E+01	-0.226E+01	-0.255E+01	-0.279E+01	-0.295E+01
-0.299E+01	-0.284E+01	-0.249E+01	-0.205E+01	-0.163E+01	-0.132E+01	-0.113E+01
-0.998E+00	-0.847E+00	-0.567E+00	-0.501E-02	0.653E+00	0.130E+01	0.166E+01
0.174E+01	0.164E+01	0.160E+01	0.168E+01	0.180E+01	0.185E+01	0.180E+01
0.174E+01	0.175E+01	0.181E+01	0.185E+01	0.176E+01	0.155E+01	0.132E+01
0.115E+01	0.109E+01	0.116E+01	0.121E+01	0.121E+01	0.111E+01	0.981E+00
0.916E+00	0.872E+00	0.776E+00	0.563E+00	0.310E+00	0.898E-01	-0.376E-01
-0.158E+00	-0.319E+00	-0.529E+00	-0.741E+00	-0.780E+00	-0.742E+00	-0.624E+00
-0.607E+00	-0.705E+00	-0.913E+00	-0.117E+01	-0.136E+01	-0.142E+01	-0.123E+01
-0.901E+00	-0.512E+00	-0.259E+00	-0.174E+00	-0.175E+00	-0.208E+00	-0.238E+00
-0.31[illegible]	-0.396E+00	-0.456E+00	-0.377E+00	-0.234E+00	-0.159E+00	-0.174E+00
-0.301E+00	-0.265E+00	-0.174E-01	0.354E+00	0.753E+00	0.100E+01	0.107E+01
0.102E+01	0.910E+00	0.752E+00	0.577E+00	0.437E+00	[illegible]	0.219[illegible]
0.199E+00	0.153E+00	0.780E-01	-0.863E-02	[illegible]	-0.236E+00	-0.223E+00
-0.103E+00	0.126E+00	0.344E+00	0.585E+00	0.784E+00	0.925E+00	0.954E+00
0.798E+00	0.538E+00	0.304E+00	0.238E+00	0.360E+00	0.569E+00	0.741E+00
0.848E+00	0.884E+00	0.900E+00	0.917E+00	0.951E+00	0.927E+00	0.959E+00
0.936E+00	0.862E+00	0.744E+00	0.655E+00	0.595E+00	0.553E+00	0.409E+00
0.116E+00	-0.342E+00	-0.848E+00	-0.131E+01	-0.174E+01	-0.204E+01	-0.212E+01
-0.199E+01	-0.154E+01	-0.102E+01	-0.529E+00	-0.272E+00	-0.132E+00	-0.747E-01
0.189E-01	0.118E+00	0.264E+00	0.407E+00	0.571E+00	0.862E+00	0.119E+01
0.154E+01	0.179E+01	0.189E+01	0.194E+01	0.199E+01	0.216E+01	0.236E+01
0.249E+01	0.243E+01	0.223E+01	0.201E+01	0.184E+01	0.170E+01	0.155E+01
0.129E+01	0.100E+01	0.729E+00	0.509E+00	0.378E+00	0.260E+00	0.241E+00
0.220E+00	0.217E+00	0.131E+00	0.538E-01	-0.208E-01	0.239E-01	0.231E-01
-0.413E-01	-0.268E+00	-0.507E+00	-0.716E+00	-0.852E+00	-0.102E+01	-0.119E+01
-0.138E+01	-0.146E+01	-0.145E+01	-0.152E+01	-0.165E+01	-0.181E+01	-0.191E+01
-0.190E+01	-0.187E+01	-0.186E+01	-0.191E+01	-0.192E+01	-0.185E+01	-0.175E+01
-0.171E+01	-0.170E+01	-0.170E+01	-0.161E+01	-0.143E+01	-0.122E+01	-0.107E+01
-0.966E+00	-0.788E+00	-0.639E+00	-0.499E+00	-0.460E+00	-0.556E+00	-0.766E+00
-0.101E+01	-0.115E+01	-0.115E+01	-0.989E+00	-0.714E+00	-0.466E+00	-0.285E+00
-0.215E+00	-0.286E+00	-0.393E+00	-0.588E+00	-0.786E+00	-0.936E+00	-0.923E+00
-0.706E+00	-0.353E+00	0.897E-01	0.530E+00	0.934E+00	0.128E+01	0.152E+01
0.164E+01	0.160E+01	0.146E+01	0.127E+01	0.110E+01	0.111E+01	0.113E+01
0.122E+01	0.115E+01	0.102E+01	0.866E+00	0.847E+00	0.948E+00	0.103E+01
0.975E+00	0.692E+00	0.328E+00	-0.927E-02	-0.254E+00	-0.412E+00	-0.494E+00
-0.345E+00	0.119E-01	0.460E+00	0.743E+00	0.707E+00	0.449E+00	0.156E+00
0.652E-01	0.651E-01	0.926E-01	0.664E-01	0.907E-01	0.213E+00	0.367E+00

0.467E+00	0.446E+00	0.320E+00	0.253E+00	0.224E+00	0.192E+00	0.149E+00
0.856E-01	0.523E-01	0.438E-02	-0.620E-01	-0.163E+00	-0.214E+00	-0.154E+00
-0.377E-02	0.186E+00	0.190E+00	-0.963E-02	-0.335E+00	-0.656E+00	-0.820E+00
-0.809E+00	-0.610E+00	-0.280E+00	0.715E-01	0.405E+00	0.684E+00	0.847E+00
0.872E+00	0.771E+00	0.634E+00	0.503E+00	0.498E+00	0.553E+00	0.569E+00
0.462E+00	0.294E+00	0.144E+00	0.454E-01	0.291E-01	0.161E-01	-0.608E-01
-0.156E+00	-0.294E+00	-0.414E+00	-0.563E+00	-0.687E+00	-0.779E+00	-0.808E+00
-0.806E+00	-0.771E+00	-0.786E+00	-0.804E+00	-0.867E+00	-0.914E+00	-0.973E+00
-0.941E+00	-0.834E+00	-0.726E+00	-0.685E+00	-0.775E+00	-0.963E+00	-0.118E+01
-0.138E+01	-0.151E+01	-0.160E+01	-0.163E+01	-0.151E+01	-0.132E+01	-0.104E+01
-0.867E+00	-0.785E+00	-0.843E+00	-0.897E+00	-0.939E+00	-0.910E+00	-0.829E+00
-0.590E+00	-0.276E+00	0.138E+00	0.572E+00	0.901E+00	0.118E+01	0.132E+01
0.143E+01	0.146E+01	0.152E+01	0.156E+01	0.161E+01	0.167E+01	0.167E+01
0.170E+01	0.174E+01	0.182E+01	0.193E+01	0.204E+01	0.209E+01	0.205E+01
0.188E+01	0.165E+01	0.139E+01	0.123E+01	0.117E+01	0.119E+01	0.121E+01
0.119E+01	0.106E+01	0.918E+00	0.720E+00	0.485E+00	0.249E+00	0.421E-01
-0.825E-01	-0.102E+00	-0.563E-01	0.839E-02	0.836E-01	0.141E+00	0.163E+00
0.106E+00	-0.677E-02	-0.133E+00	-0.235E+00	-0.297E+00	-0.394E+00	-0.512E+00
-0.642E+00	-0.743E+00	-0.817E+00	-0.888E+00	-0.935E+00	-0.103E+01	-0.107E+01
-0.118E+01	-0.135E+01	-0.157E+01	-0.174E+01	-0.175E+01	-0.159E+01	-0.128E+01
-0.965E+00	-0.666E+00	-0.338E+00	-0.395E-01	0.263E+00	0.451E+00	0.553E+00
0.539E+00	0.445E+00	0.364E+00	0.262E+00	0.203E+00	0.190E+00	0.154E+00
0.323E-01	-0.195E+00	-0.506E+00	-0.709E+00	-0.888E+00	-0.858E+00	-0.768E+00
-0.529E+00	-0.233E+00	0.432E-01	0.242E+00	0.276E+00	0.291E+00	0.289E+00
0.331E+00	0.362E+00	0.342E+00	0.284E+00	0.230E+00	0.211E+00	0.200E+00
0.171E+00	0.140E+00	0.110E+00	0.153E+00	0.265E+00	0.449E+00	0.701E+00
0.951E+00	0.108E+01	0.102E+01	0.774E+00	0.551E+00	0.476E+00	0.617E+00
0.773E+00	0.840E+00	0.774E+00	0.706E+00	0.626E+00	0.574E+00	0.395E+00
0.122E+00	-0.200E+00	-0.453E+00	-0.510E+00	-0.432E+00	-0.283E+00	-0.121E+00
-0.480E-01	-0.824E-01	-0.258E+00	-0.486E+00	-0.698E+00	-0.874E+00	-0.917E+00
-0.855E+00	-0.721E+00	-0.469E+00	-0.242E+00	-0.567E-01	0.332E-01	0.384E-01
0.376E-01	0.808E-01	0.860E-01	0.230E+00	0.439E+00	0.784E+00	0.117E+01
0.148E+01	0.156E+01	0.148E+01	0.131E+01	0.113E+01	0.974E+00	0.846E+00
0.750E+00	0.651E+00	0.559E+00	0.421E+00	0.292E+00	0.188E+00	0.259E+00
0.435E+00	0.581E+00	0.581E+00	0.385E+00	0.106E+00	-0.150E+00	-0.291E+00
-0.372E+00	-0.453E+00	-0.558E+00	-0.662E+00	-0.751E+00	-0.783E+00	-0.789E+00
-0.790E+00	-0.840E+00	-0.899E+00	-0.941E+00	-0.910E+00	-0.815E+00	-0.731E+00
-0.698E+00	-0.777E+00	-0.817E+00	-0.817E+00	-0.687E+00	-0.573E+00	-0.504E+00
-0.544E+00	-0.613E+00	-0.688E+00	-0.764E+00	-0.776E+00	-0.764E+00	-0.714E+00
-0.593E+00	-0.531E+00	-0.461E+00	-0.424E+00	-0.342E+00	-0.266E+00	-0.156E+00
-0.652E-01	0.120E+00	0.423E+00	0.767E+00	0.112E+01	0.132E+01	0.144E+01
0.149E+01	0.162E+01	0.178E+01	0.192E+01	0.202E+01	0.201E+01	0.194E+01
0.170E+01	0.142E+01	0.115E+01	0.979E+00	0.950E+00	0.982E+00	0.102E+01
0.103E+01	0.102E+01	0.963E+00	0.799E+00	0.525E+00	0.215E+00	0.494E-01
0.970E-01	0.330E+00	0.596E+00	0.782E+00	0.830E+00	0.794E+00	0.606E+00
0.348E+00	0.719E-01	-0.158E+00	-0.267E+00	-0.292E+00	-0.361E+00	-0.456E+00
-0.576E+00	-0.649E+00	-0.697E+00	-0.702E+00	-0.693E+00	-0.638E+00	-0.462E+00
-0.258E+00	-0.193E-01	0.669E-01	0.596E-01	-0.370E-01	-0.122E+00	-0.230E+00
-0.348E+00	-0.382E+00	-0.346E+00	-0.183E+00	0.155E-02	0.119E+00	0.115E+00
0.425E-01	-0.653E-01	-0.122E+00	-0.328E-01	0.372E-01	0.181E+00	0.211E+00
0.183E+00	0.102E+00	0.807E-01	0.930E-01	0.162E+00	0.138E+00	0.105E+00
-0.112E-01	-0.115E+00	-0.238E+00	-0.389E+00	-0.524E+00	-0.615E+00	-0.601E+00
-0.545E+00	-0.454E+00	-0.451E+00	-0.537E+00	-0.675E+00	-0.790E+00	-0.906E+00
-0.983E+00	-0.109E+01	-0.122E+01	-0.131E+01	-0.133E+01	-0.129E+01	-0.125E+01
-0.119E+01	-0.118E+01	-0.109E+01	-0.948E+00	-0.758E+00	-0.551E+00	-0.456E+00
-0.407E+00	-0.357E+00	-0.271E+00	-0.104E+00	0.437E-01	0.112E+00	0.681E-01

0.293E-01	0.614E-01	-0.258E-01	-0.182E+00	-0.480E+00	-0.733E+00	-0.842E+00
-0.804E+00	-0.597E+00	-0.386E+00	-0.197E+00	-0.105E+00	-0.285E-01	0.906E-01
0.207E+00	0.414E+00	0.741E+00	0.108E+01	0.146E+01	0.164E+01	0.163E+01
0.149E+01	0.135E+01	0.128E+01	0.126E+01	0.123E+01	0.114E+01	0.103E+01
0.869E+00	0.734E+00	0.639E+00	0.495E+00	0.481E+00	0.500E+00	0.585E+00
0.601E+00	0.521E+00	0.328E+00	0.418E-01	-0.261E+00	-0.496E+00	-0.646E+00
-0.708E+00	-0.731E+00	-0.719E+00	-0.776E+00	-0.931E+00	-0.118E+01	-0.152E+01
-0.182E+01	-0.196E+01	-0.193E+01	-0.174E+01	-0.151E+01	-0.128E+01	-0.107E+01
-0.845E+00	-0.585E+00	-0.399E+00	-0.287E+00	-0.192E+00	0.487E-01	0.427E+00
0.775E+00	0.972E+00	0.953E+00	0.775E+00	0.541E+00	0.409E+00	0.256E+00
0.888E-01	-0.347E-01	-0.448E-01	0.677E-01	0.275E+00	0.495E+00	0.673E+00
0.779E+00	0.851E+00	0.822E+00	0.705E+00	0.478E+00	0.144E+00	-0.185E+00
-0.454E+00	-0.599E+00	-0.623E+00	-0.560E+00	-0.560E+00	-0.648E+00	-0.816E+00
-0.907E+00	-0.921E+00	-0.789E+00	-0.658E+00	-0.583E+00	-0.502E+00	-0.427E+00
-0.347E+00	-0.312E+00	-0.339E+00	-0.402E+00	-0.428E+00	-0.422E+00	-0.475E+00
-0.584E+00	-0.700E+00	-0.795E+00	-0.860E+00	-0.836E+00	-0.780E+00	-0.622E+00
-0.347E+00	-0.931E-02	0.401E+00	0.749E+00	0.111E+01	0.139E+01	0.158E+01
0.167E+01	0.166E+01	0.160E+01	0.147E+01	0.128E+01	0.104E+01	0.781E+00
0.553E+00	0.358E+00	0.200E+00	0.542E-01	0.105E-01	0.191E+00	0.508E+00
0.816E+00	0.948E+00	0.837E+00	0.635E+00	0.424E+00	0.304E+00	0.193E+00
0.459E-01	-0.963E-01	-0.212E+00	-0.270E+00	-0.374E+00	-0.530E+00	-0.689E+00
-0.816E+00	-0.836E+00	-0.751E+00	-0.523E+00	-0.150E+00	0.285E+00	0.658E+00
0.807E+00	0.693E+00	0.432E+00	0.120E+00	-0.160E+00	-0.447E+00	-0.738E+00
-0.975E+00	-0.115E+01	-0.126E+01	-0.136E+01	-0.149E+01	-0.160E+01	-0.167E+01
-0.162E+01	-0.148E+01	-0.125E+01	-0.923E+00	-0.570E+00	-0.206E+00	0.649E-01
0.211E+00	0.256E+00	0.219E+00	0.185E+00	0.103E+00	0.122E+00	0.173E+00
0.298E+00	0.350E+00	0.308E+00	0.222E+00	0.156E+00	0.200E+00	0.294E+00
0.363E+00	0.327E+00	0.291E+00	0.259E+00	0.305E+00	0.367E+00	0.441E+00
0.519E+00	0.610E+00	0.667E+00	0.675E+00	0.617E+00	0.556E+00	0.509E+00
0.505E+00	0.595E+00	0.708E+00	0.815E+00	0.892E+00	0.884E+00	0.800E+00
0.751E+00	0.747E+00	0.726E+00	0.629E+00	0.449E+00	0.212E+00	0.254E-01
-0.548E-01	-0.420E-01	-0.768E-02	0.445E-01	0.127E+00	0.236E+00	0.288E+00
0.291E+00	0.217E+00	0.156E+00	0.139E+00	0.152E+00	0.198E+00	0.256E+00
0.397E+00	0.548E+00	0.694E+00	0.692E+00	0.581E+00	0.423E+00	0.208E+00
-0.270E-01	-0.273E+00	-0.481E+00	-0.568E+00	-0.485E+00	-0.349E+00	-0.182E+00
-0.657E-01	0.278E-01	0.141E+00	0.230E+00	0.303E+00	0.347E+00	0.411E+00
0.506E+00	0.553E+00	0.569E+00	0.431E+00	0.253E+00	0.104E+00	0.220E-01
0.110E-01	-0.133E-02	0.690E-02	-0.229E-01	-0.439E-01	-0.121E+00	-0.241E+00
-0.362E+00	-0.513E+00	-0.628E+00	-0.693E+00	-0.663E+00	-0.610E+00	-0.523E+00
-0.508E+00	-0.585E+00	-0.669E+00	-0.710E+00	-0.667E+00	-0.547E+00	-0.414E+00
-0.291E+00	-0.166E+00	-0.204E-01	0.159E+00	0.303E+00	0.373E+00	0.386E+00
0.360E+00	0.274E+00	0.141E+00	0.444E-01	-0.769E-01	-0.110E+00	-0.157E+00
-0.192E+00	-0.296E+00	-0.427E+00	-0.582E+00	-0.660E+00	-0.659E+00	-0.586E+00
-0.412E+00	-0.218E+00	-0.373E-01	0.117E+00	0.212E+00	0.268E+00	0.284E+00
0.280E+00	0.221E+00	0.199E+00	0.212E+00	0.282E+00	0.344E+00	0.376E+00
0.316E+00	0.224E+00	0.900E-01	-0.257E-01	-0.103E+00	-0.153E+00	-0.148E+00
-0.668E-01	0.716E-01	0.195E+00	0.239E+00	0.185E+00	0.435E-01	-0.107E+00
-0.185E+00	-0.207E+00	-0.155E+00	-0.126E+00	-0.164E+00	-0.262E+00	-0.393E+00
-0.487E+00	-0.523E+00	-0.517E+00	-0.433E+00	-0.357E+00	-0.266E+00	-0.131E+00
0.278E-01	0.224E+00	0.472E+00	0.677E+00	0.825E+00	0.853E+00	0.791E+00
0.707E+00	0.604E+00	0.544E+00	0.474E+00	0.370E+00	0.309E+00	0.294E+00
0.350E+00	0.417E+00	0.424E+00	0.361E+00	0.291E+00	0.225E+00	0.215E+00
0.180E+00	0.749E-01	-0.797E-01	-0.225E+00	-0.324E+00	-0.390E+00	-0.466E+00
-0.588E+00	-0.706E+00	-0.822E+00	-0.866E+00	-0.882E+00	-0.858E+00	-0.772E+00
-0.624E+00	-0.423E+00	-0.203E+00	-0.948E-01	-0.715E-01	-0.145E+00	-0.215E+00
-0.271E+00	-0.289E+00	-0.243E+00	-0.165E+00	-0.471E-01	0.652E-01	0.678E-01
-0.376E-01	-0.193E+00	-0.345E+00	-0.409E+00	-0.408E+00	-0.362E+00	-0.319E+00
-0.278E+00	-0.225E+00	-0.161E+00	-0.412E-01	0.803E-01	0.232E+00	0.329E+00
0.389E+00	0.374E+00	0.302E+00	0.249E+00	0.189E+00	0.114E+00	0.117E-01
-0.127E+00	-0.277E+00	-0.309E+00	-0.275E+00	-0.165E+00	-0.135E+00	-0.137E+00

-0.173E+00	-0.194E+00	-0.101E+00	0.286E-01	0.172E+00	0.286E+00	0.351E+00
0.386E+00	0.422E+00	0.406E+00	0.388E+00	0.366E+00	0.333E+00	0.320E+00
0.289E+00	0.248E+00	0.223E+00	0.200E+00	0.224E+00	0.259E+00	0.270E+00
0.261E+00	0.211E+00	0.185E+00	0.147E+00	0.142E+00	0.575E-01	-0.782E-01
-0.253E+00	-0.457E+00	-0.609E+00	-0.719E+00	-0.812E+00	-0.829E+00	-0.795E+00
-0.648E+00	-0.433E+00	-0.190E+00	0.322E-01	0.207E+00	0.354E+00	0.444E+00
0.475E+00	0.425E+00	0.306E+00	0.189E+00	0.105E+00	0.930E-01	0.932E-01
0.988E-01	0.905E-01	0.134E+00	0.121E+00	0.789E-01	-0.545E-01	-0.248E+00
-0.398E+00	-0.453E+00	-0.373E+00	-0.226E+00	-0.983E-01	-0.233E-01	-0.603E-02
-0.748E-01	-0.149E+00	-0.249E+00	-0.335E+00	-0.363E+00	-0.321E+00	-0.300E+00
-0.265E+00	-0.278E+00	-0.292E+00	-0.288E+00	-0.284E+00	-0.279E+00	-0.255E+00
-0.218E+00	-0.106E+00	0.564E-01	0.292E+00	0.500E+00	0.651E+00	0.701E+00
0.642E+00	0.515E+00	0.373E+00	0.229E+00	0.135E+00	0.642E-01	0.316E-02
-0.414E-01	-0.845E-01	-0.627E-01	-0.925E-02	0.495E-01	0.435E-01	-0.298E-01
-0.161E+00	-0.296E+00	-0.368E+00	-0.404E+00	-0.366E+00	-0.275E+00	-0.170E+00
-0.394E-01	0.446E-01	0.615E-01	0.120E-01	-0.451E-01	-0.594E-01	-0.144E-01
0.111E+00	0.235E+00	0.353E+00	0.374E+00	0.305E+00	0.112E+00	-0.120E+00
-0.319E+00	-0.407E+00	-0.366E+00	-0.252E+00	-0.127E+00	-0.257E-01	0.304E-01
0.108E+00	0.208E+00	0.335E+00	0.501E+00	0.619E+00	0.713E+00	0.747E+00
0.757E+00	0.747E+00	0.746E+00	0.687E+00	0.619E+00	0.489E+00	0.345E+00
0.200E+00	0.617E-01	-0.525E-01	-0.817E-01	-0.763E-01	0.248E-02	0.396E-01
0.383E-01	-0.220E-01	-0.745E-01	-0.152E+00	-0.157E+00	-0.180E+00	-0.203E+00
-0.247E+00	-0.284E+00	-0.285E+00	-0.256E+00	-0.172E+00	-0.874E-01	0.164E-01
0.133E+00	0.215E+00	0.291E+00	0.341E+00	0.379E+00	0.424E+00	0.419E+00
0.401E+00	0.314E+00	0.242E+00	0.186E+00	0.158E+00	0.178E+00	0.239E+00
0.344E+00	0.454E+00	0.552E+00	0.566E+00	0.517E+00	0.381E+00	0.220E+00
0.620E-01	-0.970E-01	-0.249E+00	-0.391E+00	-0.506E+00	-0.555E+00	-0.592E+00
-0.561E+00	-0.517E+00	-0.462E+00	-0.399E+00	-0.292E+00	-0.162E+00	0.113E-01
0.160E+00	0.314E+00	0.425E+00	0.545E+00	0.628E+00	0.676E+00	0.691E+00
0.627E+00	0.506E+00	0.360E+00	0.236E+00	0.116E+00	0.132E-01	-0.631E-01
-0.146E+00	-0.215E+00	-0.261E+00	-0.287E+00	-0.306E+00	-0.276E+00	-0.297E+00
-0.316E+00	-0.330E+00	-0.321E+00	-0.275E+00	-0.218E+00	-0.159E+00	-0.172E+00
-0.188E+00	-0.233E+00	-0.239E+00	-0.189E+00	-0.122E+00	-0.270E-01	0.728E-01
0.170E+00	0.251E+00	0.296E+00	0.287E+00	0.195E+00	0.481E-01	-0.142E+00
-0.305E+00	-0.385E+00	-0.430E+00	-0.427E+00	-0.436E+00	-0.433E+00	-0.437E+00
-0.414E+00	-0.374E+00	-0.342E+00	-0.320E+00	-0.278E+00	-0.217E+00	-0.114E+00
-0.157E-01	0.583E-01	0.988E-01	0.791E-01	0.355E-01	-0.381E-01	-0.142E+00
-0.212E+00	0.267E+00	-0.253E+00	-0.213E+00	-0.159E+00	-0.130E+00	-0.119E+00
-0.144E+00	-0.169E+00	-0.208E+00	-0.261E+00	-0.303E+00	-0.333E+00	-0.323E+00
-0.344E+00	-0.364E+00	-0.432E+00	-0.538E+00	-0.661E+00	-0.785E+00	-0.867E+00
-0.941E+00	-0.970E+00	-0.976E+00	-0.894E+00	-0.752E+00	-0.529E+00	-0.287E+00
-0.900E-01	0.312E-01	0.759E-01	0.806E-01	0.900E-01	0.984E-01	0.147E+00
0.203E+00	0.272E+00	0.343E+00	0.376E+00	0.354E+00	0.294E+00	0.217E+00
0.201E+00	0.200E+00	0.217E+00	0.227E+00	0.189E+00	0.154E+00	0.123E+00
0.996E-01	0.945E-01	0.881E-01	0.765E-01	0.706E-01	0.944E-01	0.105E+00
0.146E+00	0.198E+00	0.243E+00	0.294E+00	0.354E+00	0.436E+00	0.518E+00
0.595E+00	0.635E+00	0.630E+00	0.604E+00	0.569E+00	0.531E+00	0.511E+00
0.481E+00	0.449E+00	0.421E+00	0.401E+00	0.402E+00	0.374E+00	0.352E+00
0.308E+00	0.264E+00	0.252E+00	0.266E+00	0.270E+00	0.270E+00	0.254E+00
0.186E+00	0.113E+00	0.287E-01	-0.886E-02	-0.294E-01	0.167E-03	0.424E-01
0.942E-01	0.159E+00	0.218E+00	0.288E+00	0.349E+00	0.392E+00	0.395E+00
0.364E+00	0.282E+00	0.130E+00	-0.169E-01	-0.163E+00	-0.238E+00	-0.254E+00
-0.214E+00	-0.144E+00	-0.751E-01	-0.215E-01	0.161E-01	0.609E-01	0.131E+00
0.202E+00	0.291E+00	0.330E+00	0.362E+00	0.380E+00	0.376E+00	0.348E+00
0.282E+00	0.202E+00	0.112E+00	0.721E-01	0.668E-01	0.107E+00	0.127E+00
0.145E+00	0.128E+00	0.826E-01	-0.486E-02	-0.127E+00	-0.264E+00	-0.354E+00
-0.439E+00	-0.459E+00	-0.434E+00	-0.362E+00	-0.256E+00	-0.119E+00	-0.699E-02
0.611E-01	0.401E-01	-0.119E-01	-0.385E-01	-0.216E-01	0.352E-01	0.110E+00
0.151E+00	0.169E+00	0.146E+00	0.930E-01	0.253E-01	-0.544E-01	-0.128E+00
-0.180E+00	-0.205E+00	-0.218E+00	-0.228E+00	-0.220E+00	-0.207E+00	-0.162E+00

-0.129E+00	-0.116E+00	-0.178E+00	-0.264E+00	-0.367E+00	-0.436E+00	-0.455E+00
-0.438E+00	-0.414E+00	-0.391E+00	-0.369E+00	-0.383E+00	-0.381E+00	-0.381E+00
-0.345E+00	-0.316E+00	-0.269E+00	-0.238E+00	-0.180E+00	-0.121E+00	-0.636E-01
-0.286E-01	-0.261E-01	-0.622E-01	-0.961E-01	-0.940E-01	-0.874E-01	-0.525E-01
-0.839E-02	0.328E-01	0.690E-01	0.788E-01	0.412E-01	-0.669E-01	-0.212E+00
-0.362E+00	-0.445E+00	-0.490E+00	-0.483E+00	-0.405E+00	-0.320E+00	-0.239E+00
-0.196E+00	-0.197E+00	-0.205E+00	-0.188E+00	-0.126E+00	-0.287E-01	0.686E-01
0.133E+00	0.168E+00	0.176E+00	0.166E+00	0.137E+00	0.127E+00	0.116E+00
0.141E+00	0.181E+00	0.231E+00	0.292E+00	0.369E+00	0.462E+00	0.579E+00
0.669E+00	0.721E+00	0.722E+00	0.681E+00	0.628E+00	0.597E+00	0.603E+00
0.631E+00	0.651E+00	0.620E+00	0.556E+00	0.456E+00	0.368E+00	0.301E+00
0.234E+00	0.197E+00	0.157E+00	0.142E+00	0.151E+00	0.150E+00	0.129E+00
0.922E-01	0.587E-01	0.372E-01	0.252E-01	0.336E-01	0.484E-01	0.870E-01
0.125E+00	0.148E+00	0.153E+00	0.118E+00	0.815E-01	0.479E-01	0.294E-01
0.357E-01	0.478E-01	0.824E-01	0.143E+00	0.210E+00	0.261E+00	0.274E+00
0.242E+00	0.202E+00	0.197E+00	0.222E+00	0.233E+00	0.162E+00	-0.171E-01
-0.293E+00	-0.570E+00	-0.801E+00	-0.958E+00	-0.104E+01	-0.109E+01	-0.111E+01
-0.108E+01	-0.103E+01	-0.985E+00	-0.952E+00	-0.927E+00	-0.896E+00	-0.835E+00
-0.726E+00	-0.614E+00	-0.500E+00	-0.396E+00	-0.295E+00	-0.201E+00	-0.108E+00
-0.184E-01	0.372E-01	0.975E-01	0.129E+00	0.169E+00	0.204E+00	0.254E+00
0.299E+00	0.334E+00	0.361E+00	0.399E+00	0.438E+00	0.483E+00	0.502E+00
0.494E+00	0.435E+00	0.320E+00	0.175E+00	0.204E-01	-0.136E+00	-0.271E+00
-0.426E+00	-0.603E+00	-0.818E+00	-0.108E+01	-0.128E+01	-0.140E+01	-0.141E+01
-0.130E+01	-0.114E+01	-0.913E+00	-0.649E+00	-0.371E+00	-0.108E+00	0.101E+00
0.241E+00	0.334E+00	0.415E+00	0.487E+00	0.529E+00	0.563E+00	0.546E+00
0.523E+00	0.463E+00	0.394E+00	0.333E+00	0.273E+00	0.238E+00	0.232E+00
0.264E+00	0.333E+00	0.437E+00	0.530E+00	0.582E+00	0.601E+00	0.599E+00
0.601E+00	0.632E+00	0.644E+00	0.643E+00	0.545E+00	0.372E+00	0.145E+00
-0.112E+00	-0.337E+00	-0.491E+00	-0.563E+00	-0.581E+00	-0.547E+00	-0.503E+00
-0.453E+00	-0.396E+00	-0.364E+00	-0.355E+00	-0.358E+00	-0.324E+00	-0.250E+00
-0.124E+00	-0.683E-02	0.902E-01	0.169E+00	0.255E+00	0.348E+00	0.432E+00
0.463E+00	0.455E+00	0.427E+00	0.404E+00	0.413E+00	0.422E+00	0.441E+00
0.446E+00	0.446E+00	0.429E+00	0.400E+00	0.332E+00	0.245E+00	0.152E+00
0.561E-01	0.159E-01	-0.349E-02	0.386E-02	0.209E-01	-0.328E-02	-0.234E-01
-0.465E-01	-0.589E-01	-0.530E-01	-0.592E-01	-0.662E-01	-0.498E-01	0.461E-02
0.974E-01	0.212E+00	0.318E+00	0.403E+00	0.441E+00	0.455E+00	0.422E+00
0.363E+00	0.310E+00	0.283E+00	0.302E+00	0.348E+00	0.391E+00	0.409E+00
0.419E+00	0.406E+00	0.391E+00	0.374E+00	0.333E+00	0.291E+00	0.241E+00
0.203E+00	0.174E+00	0.162E+00	0.136E+00	0.115E+00	0.837E-01	0.536E-01
0.316E-01	0.293E-01	0.421E-01	0.405E-01	0.438E-01	0.388E-01	0.163E-01
0.102E-01	-0.124E-01	-0.601E-01	-0.130E+00	-0.195E+00	-0.260E+00	-0.279E+00
-0.274E+00	-0.258E+00	-0.219E+00	-0.210E+00	-0.189E+00	-0.201E+00	-0.248E+00
-0.326E+00	-0.392E+00	-0.432E+00	-0.407E+00	-0.348E+00	-0.293E+00	-0.264E+00
-0.262E+00	-0.287E+00	-0.343E+00	-0.426E+00	-0.536E+00	-0.610E+00	-0.626E+00
-0.601E+00	-0.604E+00	-0.739E+00	-0.987E+00	-0.126E+01	-0.148E+01	-0.160E+01
-0.164E+01	-0.167E+01	-0.168E+01	-0.162E+01	-0.150E+01	-0.131E+01	-0.110E+01
-0.924E+00	-0.784E+00	-0.650E+00	-0.521E+00	-0.370E+00	-0.204E+00	-0.414E-01
0.927E-01	0.176E+00	0.201E+00	0.217E+00	0.245E+00	0.298E+00	0.340E+00
0.367E+00	0.356E+00	0.365E+00	0.392E+00	0.427E+00	0.442E+00	0.416E+00
0.349E+00	0.237E+00	0.969E-01	-0.408E-01	-0.156E+00	-0.238E+00	-0.293E+00
-0.324E+00	-0.330E+00	-0.322E+00	-0.275E+00	-0.242E+00	-0.183E+00	-0.132E+00
-0.655E-01	0.212E-01	0.120E+00	0.205E+00	0.300E+00	0.403E+00	0.541E+00
0.678E+00	0.787E+00	0.854E+00	0.882E+00	0.903E+00	0.938E+00	0.959E+00
0.949E+00	0.901E+00	0.833E+00	0.750E+00	0.655E+00	0.548E+00	0.436E+00
0.334E+00	0.254E+00	0.184E+00	0.135E+00	0.926E-01	0.391E-01	-0.630E-01
-0.242E+00	-0.485E+00	-0.713E+00	-0.859E+00	-0.884E+00	-0.805E+00	-0.677E+00
-0.545E+00	-0.428E+00	-0.329E+00	-0.256E+00	-0.192E+00	-0.136E+00	-0.587E-01
0.179E-01	0.728E-01	0.922E-01	0.805E-01	0.639E-01	0.518E-01	0.503E-01
0.420E-01	0.278E-01	0.163E-01	0.544E-01	0.118E+00	0.169E+00	0.204E+00
0.186E+00	0.131E+00	0.753E-01	0.203E-01	0.167E-01	0.478E-01	0.826E-01

0.127E+00	0.144E+00	0.164E+00	0.170E+00	0.178E+00	0.149E+00	0.944E-01
0.120E-01	-0.855E-01	-0.164E+00	-0.253E+00	-0.334E+00	-0.402E+00	-0.429E+00
-0.413E+00	-0.369E+00	-0.303E+00	-0.236E+00	-0.147E+00	-0.698E-01	-0.105E-01
0.121E-01	0.858E-02	0.218E-01	0.569E-01	0.104E+00	0.169E+00	0.202E+00
0.224E+00	0.230E+00	0.263E+00	0.297E+00	0.352E+00	0.402E+00	0.421E+00
0.407E+00	0.394E+00	0.409E+00	0.476E+00	0.548E+00	0.567E+00	0.475E+00
0.300E+00	0.104E+00	-0.556E-01	-0.157E+00	-0.209E+00	-0.237E+00	-0.234E+00
-0.195E+00	-0.145E+00	-0.815E-01	-0.214E-01	0.554E-01	0.149E+00	0.257E+00
0.362E+00	0.447E+00	0.512E+00	0.534E+00	0.513E+00	0.433E+00	0.306E+00
0.145E+00	-0.133E-01	-0.125E+00	-0.177E+00	-0.153E+00	-0.107E+00	-0.564E-01
-0.236E-01	0.151E-01	0.737E-01	0.172E+00	0.270E+00	0.336E+00	0.366E+00
0.356E+00	0.318E+00	0.264E+00	0.178E+00	0.738E-01	-0.471E-01	-0.141E+00
-0.207E+00	-0.265E+00	-0.308E+00	-0.368E+00	-0.436E+00	-0.537E+00	-0.584E+00
-0.596E+00	-0.516E+00	-0.399E+00	-0.260E+00	-0.148E+00	-0.898E-01	-0.542E-01
-0.160E-01	0.453E-01	0.128E+00	0.227E+00	0.307E+00	0.361E+00	0.370E+00
0.348E+00	0.310E+00	0.286E+00	0.263E+00	0.239E+00	0.229E+00	0.221E+00
0.249E+00	0.296E+00	0.345E+00	0.358E+00	0.379E+00	0.382E+00	0.385E+00
0.344E+00	0.247E+00	0.111E+00	-0.239E-01	-0.128E+00	-0.194E+00	-0.255E+00
-0.305E+00	-0.348E+00	-0.364E+00	-0.361E+00	-0.342E+00	-0.315E+00	-0.260E+00
-0.186E+00	-0.122E+00	-0.529E-01	-0.386E-01	-0.184E-01	-0.109E-01	0.388E-01
0.850E-01	0.159E+00	0.230E+00	0.274E+00	0.255E+00	0.227E+00	0.179E+00
0.175E+00	0.216E+00	0.279E+00	0.333E+00	0.386E+00	0.402E+00	0.407E+00
0.406E+00	0.382E+00	0.359E+00	0.339E+00	0.347E+00	0.349E+00	0.319E+00
0.274E+00	0.185E+00	0.926E-01	0.278E-01	-0.977E-02	-0.207E-01	-0.237E-01
-0.332E-01	-0.534E-01	-0.654E-01	-0.806E-01	-0.734E-01	-0.972E-01	-0.148E+00
-0.217E+00	-0.284E+00	-0.315E+00	-0.284E+00	-0.246E+00	-0.217E+00	-0.212E+00
-0.214E+00	-0.181E+00	-0.985E-01	0.154E-01	0.133E+00	0.222E+00	0.269E+00
0.298E+00	0.333E+00	0.377E+00	0.458E+00	0.534E+00	0.595E+00	0.633E+00
0.626E+00	0.597E+00	0.543E+00	0.466E+00	0.386E+00	0.321E+00	0.245E+00
0.150E+00	0.500E-01	-0.452E-01	-0.110E+00	-0.137E+00	-0.124E+00	-0.123E+00
-0.152E+00	-0.184E+00	-0.251E+00	-0.286E+00	-0.291E+00	-0.265E+00	-0.228E+00
-0.198E+00	-0.202E+00	-0.239E+00	-0.281E+00	-0.282E+00	-0.222E+00	-0.134E+00
-0.240E-01	0.106E+00	0.223E+00	0.345E+00	0.454E+00	0.521E+00	0.540E+00
0.502E+00	0.424E+00	0.335E+00	0.248E+00	0.200E+00	0.185E+00	0.179E+00
0.179E+00	0.148E+00	0.103E+00	0.420E-01	-0.181E-01	-0.958E-01	-0.168E+00
-0.252E+00	-0.336E+00	-0.407E+00	-0.451E+00	-0.463E+00	-0.423E+00	-0.342E+00
-0.270E+00	-0.213E+00	-0.190E+00	-0.177E+00	-0.159E+00	-0.150E+00	-0.137E+00
-0.129E+00	-0.106E+00	-0.741E-01	-0.395E-01	-0.153E-01	-0.103E-01	-0.224E-01
-0.191E-01	0.538E-02	0.547E-01	0.145E+00	0.252E+00	0.357E+00	0.421E+00
0.437E+00	0.406E+00	0.356E+00	0.283E+00	0.223E+00	0.169E+00	0.101E+00
0.501E-01	0.199E-01	-0.618E-02	-0.311E-01	-0.628E-01	-0.130E+00	-0.212E+00
-0.315E+00	-0.400E+00	-0.455E+00	-0.461E+00	-0.433E+00	-0.389E+00	-0.349E+00
-0.309E+00	-0.296E+00	-0.295E+00	-0.320E+00	-0.352E+00	-0.372E+00	-0.356E+00
-0.305E+00	-0.248E+00	-0.192E+00	-0.189E+00	-0.190E+00	-0.203E+00	-0.205E+00
-0.197E+00	-0.184E+00	-0.157E+00	-0.124E+00	-0.817E-01	-0.325E-01	0.231E-01
0.436E-01	0.261E-01	-0.617E-01	-0.183E+00	-0.307E+00	-0.374E+00	-0.381E+00
-0.343E+00	-0.298E+00	-0.261E+00	-0.216E+00	-0.178E+00	-0.134E+00	-0.991E-01
-0.927E-01	-0.921E-01	-0.117E+00	-0.159E+00	-0.232E+00	-0.306E+00	-0.357E+00
-0.371E+00	-0.345E+00	-0.301E+00	-0.252E+00	-0.203E+00	-0.133E+00	-0.506E-01
0.436E-01	0.141E+00	0.233E+00	0.309E+00	0.351E+00	0.358E+00	0.357E+00
0.355E+00	0.381E+00	0.421E+00	0.430E+00	0.433E+00	0.406E+00	0.360E+00
0.307E+00	0.237E+00	0.147E+00	0.691E-01	0.750E-02	0.380E-02	0.222E-01
0.498E-01	0.817E-01	0.974E-01	0.112E+00	0.133E+00	0.141E+00	0.152E+00
0.143E+00	0.118E+00	0.754E-01	0.303E-01	-0.865E-02	-0.310E-01	-0.544E-01
-0.597E-01	-0.589E-01	-0.385E-01	-0.168E-02	0.418E-01	0.861E-01	0.126E+00
0.166E+00	0.209E+00	0.241E+00	0.245E+00	0.219E+00	0.159E+00	0.942E-01
0.292E-01	-0.192E-01	-0.611E-01	-0.825E-01	-0.846E-01	-0.505E-01	-0.884E-02
0.402E-01	0.869E-01	0.107E+00	0.107E+00	0.859E-01	0.367E-01	-0.103E-01
-0.466E-01	-0.691E-01	-0.544E-01	-0.482E-01	-0.394E-01	-0.361E-01	-0.306E-01
-0.349E-01	-0.303E-01	-0.241E-01	-0.190E-01	-0.337E-01	-0.726E-01	-0.122E+00

-0.160E+00	-0.172E+00	-0.149E+00	-0.123E+00	-0.100E+00	-0.739E-01	-0.534E-01
-0.291E-01	0.282E-02	0.298E-01	0.643E-01	0.756E-01	0.666E-01	0.314E-01
-0.274E-01	-0.689E-01	-0.998E-01	-0.116E+00	-0.121E+00	-0.141E+00	-0.151E+00
-0.152E+00	-0.129E+00	-0.121E+00	-0.112E+00	-0.103E+00	-0.766E-01	-0.407E-01
-0.171E-03	0.211E-01	0.311E-01	0.314E-01	0.525E-01	0.581E-01	0.687E-01
0.631E-01	0.550E-01	0.517E-01	0.568E-01	0.567E-01	0.602E-01	0.626E-01
0.602E-01	0.414E-01	0.653E-02	-0.368E-01	-0.684E-01	-0.885E-01	-0.830E-01
-0.631E-01	-0.102E-01	0.579E-01	0.146E+00	0.212E+00	0.266E+00	0.294E+00
0.323E+00	0.352E+00	0.353E+00	0.318E+00	0.253E+00	0.179E+00	0.106E+00
0.610E-01	0.219E-01	-0.150E-01	-0.608E-01	-0.973E-01	-0.119E+00	-0.107E+00
-0.779E-01	-0.418E-01	-0.172E-01	-0.106E-01	-0.516E-02	0.189E-01	0.896E-01
0.181E+00	0.276E+00	0.345E+00	0.373E+00	0.388E+00	0.372E+00	0.345E+00
0.303E+00	0.257E+00	0.189E+00	0.119E+00	0.362E-01	-0.602E-01	-0.143E+00
-0.234E+00	-0.310E+00	-0.390E+00	-0.465E+00	-0.538E+00	-0.607E+00	-0.650E+00
-0.672E+00	-0.657E+00	-0.609E+00	-0.534E+00	-0.450E+00	-0.355E+00	-0.264E+00
-0.162E+00	-0.784E-01	-0.296E-02	0.530E-01	0.110E+00	0.181E+00	0.247E+00
0.277E+00	0.243E+00	0.161E+00	0.603E-01	-0.172E-01	-0.882E-01	-0.142E+00
-0.215E+00	-0.287E+00	-0.365E+00	-0.434E+00	-0.478E+00	-0.489E+00	-0.462E+00
-0.391E+00	-0.284E+00	-0.165E+00	-0.524E-01	0.546E-01	0.139E+00	0.213E+00
0.239E+00	0.247E+00	0.226E+00	0.191E+00	0.142E+00	0.759E-01	0.322E-02
-0.633E-01	-0.985E-01	-0.110E+00	-0.928E-01	-0.773E-01	-0.478E-01	-0.212E-01
0.761E-02	0.587E-02	-0.135E-01	-0.499E-01	-0.810E-01	-0.924E-01	-0.785E-01
-0.327E-01	0.305E-01	0.874E-01	0.110E+00	0.760E-01	-0.480E-02	-0.931E-01
-0.160E+00	-0.179E+00	-0.182E+00	-0.190E+00	-0.231E+00	-0.276E+00	-0.334E+00
-0.365E+00	-0.367E+00	-0.337E+00	-0.309E+00	-0.269E+00	-0.233E+00	-0.196E+00
-0.135E+00	-0.701E-01	-0.966E-02	0.270E-01	0.252E-01	-0.169E-02	-0.443E-01
-0.874E-01	-0.131E+00	-0.148E+00	-0.147E+00	-0.118E+00	-0.700E-01	-0.151E-01
0.442E-01	0.112E+00	0.168E+00	0.244E+00	0.306E+00	0.383E+00	0.465E+00
0.526E+00	0.569E+00	0.560E+00	0.511E+00	0.440E+00	0.362E+00	0.301E+00
0.257E+00	0.226E+00	0.193E+00	0.171E+00	0.146E+00	0.117E+00	0.892E-01
0.632E-01	0.399E-01	0.435E-01	0.707E-01	0.119E+00	0.182E+00	0.217E+00
0.218E+00	0.169E+00	0.754E-01	-0.341E-01	-0.148E+00	-0.246E+00	-0.336E+00
-0.415E+00	-0.497E+00	-0.568E+00	-0.611E+00	-0.621E+00	-0.569E+00	-0.483E+00
-0.378E+00	-0.264E+00	-0.156E+00	-0.429E-01	0.686E-01	0.174E+00	0.264E+00
0.327E+00	0.372E+00	0.396E+00	0.407E+00	0.402E+00	0.384E+00	0.359E+00
0.322E+00	0.283E+00	0.227E+00	0.173E+00	0.128E+00	0.971E-01	0.873E-01
0.726E-01	0.635E-01	0.718E-01	0.914E-01	0.107E+00	0.581E-01	-0.487E-01
-0.230E+00	-0.407E+00	-0.543E+00	-0.609E+00	-0.624E+00	-0.619E+00	-0.618E+00
-0.617E+00	-0.610E+00	-0.582E+00	-0.560E+00	-0.521E+00	-0.489E+00	-0.440E+00
-0.377E+00	-0.289E+00	-0.183E+00	-0.677E-01	0.311E-01	0.114E+00	0.162E+00
0.205E+00	0.244E+00	0.297E+00	0.372E+00	0.439E+00	0.501E+00	0.529E+00
0.538E+00	0.508E+00	0.468E+00	0.403E+00	0.337E+00	0.258E+00	0.180E+00
0.983E-01	0.283E-01	-0.514E-01	-0.115E+00	-0.184E+00	-0.233E+00	-0.254E+00
-0.259E+00	-0.229E+00	-0.209E+00	-0.172E+00	-0.143E+00	-0.119E+00	-0.842E-01
-0.510E-01	-0.655E-02	0.603E-01	0.131E+00	0.206E+00	0.256E+00	0.293E+00
0.306E+00	0.310E+00	0.310E+00	0.299E+00	0.277E+00	0.249E+00	0.208E+00
0.172E+00	0.126E+00	0.697E-01	0.169E-01	-0.403E-01	-0.937E-01	-0.131E+00
-0.171E+00	-0.198E+00	-0.223E+00	-0.246E+00	-0.254E+00	-0.237E+00	-0.208E+00
-0.168E+00	-0.133E+00	-0.927E-01	-0.533E-01	0.226E-02	0.679E-01	0.127E+00
0.170E+00	0.197E+00	0.202E+00	0.211E+00	0.206E+00	0.181E+00	0.148E+00
0.973E-01	0.636E-01	0.433E-01	0.482E-01	0.784E-01	0.101E+00	0.108E+00
0.938E-01	0.786E-01	0.613E-01	0.605E-01	0.773E-01	0.992E-01	0.102E+00
0.953E-01	0.679E-01	0.327E-01	0.180E-02	-0.637E-02	0.755E-02	0.468E-01
0.725E-01	0.882E-01	0.904E-01	0.871E-01	0.110E+00	0.134E+00	0.153E+00
0.166E+00	0.166E+00	0.169E+00	0.183E+00	0.186E+00	0.179E+00	0.161E+00
0.151E+00	0.161E+00	0.174E+00	0.186E+00	0.182E+00	0.157E+00	0.118E+00
0.835E-01	0.605E-01	0.685E-01	0.929E-01	0.115E+00	0.123E+00	0.111E+00
0.106E+00	0.116E+00	0.140E+00	0.146E+00	0.126E+00	0.563E-01	-0.325E-01
-0.134E+00	-0.214E+00	-0.295E+00	-0.358E+00	-0.434E+00	-0.487E+00	-0.519E+00
-0.506E+00	-0.439E+00	-0.351E+00	-0.254E+00	-0.166E+00	-0.922E-01	-0.338E-01

0.181E-01	0.638E-01	0.965E-01	0.111E+00	0.127E+00	0.118E+00	0.127E+[illegible]
0.132E+00	0.136E+00	0.150E+00	0.158E+00	0.163E+00	0.158E+00	0.151E+[illegible]
0.139E+00	0.122E+00	0.105E+00	0.834E-01	0.684E-01	0.527E-01	0.379E-[illegible]
-0.629E-03	-0.372E-01	-0.716E-01	-0.973E-01	-0.963E-01	-0.921E-01	-0.772E-[illegible]
-0.678E-01	-0.589E-01	-0.407E-01	-0.153E-01	0.270E-01	0.735E-01	0.138E+[illegible]
0.200E+00	0.248E+00	0.274E+00	0.247E+00	0.193E+00	0.124E+00	0.591E-[illegible]
0.118E-01	-0.584E-02	-0.191E-01	-0.299E-01	-0.371E-01	-0.514E-01	-0.614E-[illegible]
-0.662E-01	-0.704E-01	-0.828E-01	-0.911E-01	-0.107E+00	-0.112E+00	-0.990E-[illegible]
-0.761E-01	-0.490E-01	-0.272E-01	-0.201E-01	-0.323E-01	-0.672E-01	-0.113E+[illegible]
-0.152E+00	-0.161E+00	-0.136E+00	-0.813E-01	-0.222E-01	0.236E-01	0.500E-[illegible]
0.566E-01	0.623E-01	0.640E-01	0.571E-01	0.455E-01	0.148E-01	-0.194E-[illegible]
-0.661E-01	-0.110E+00	-0.152E+00	-0.166E+00	-0.158E+00	-0.142E+00	-0.150E+[illegible]
-0.165E+00	-0.189E+00	-0.216E+00	-0.224E+00	-0.222E+00	-0.227E+00	-0.225E+[illegible]
-0.233E+00	-0.237E+00	-0.239E+00	-0.245E+00	-0.237E+00	-0.226E+00	-0.199E+[illegible]
-0.170E+00	-0.127E+00	-0.865E-01	-0.298E-01	0.153E-01	0.661E-01	0.102E+0[illegible]
0.135E+00	0.174E+00	0.203E+00	0.232E+00	0.237E+00	0.234E+00	0.231E+0[illegible]
0.225E+00	0.221E+00	0.229E+00	0.232E+00	0.229E+00	0.236E+00	0.231E+0[illegible]
0.221E+00	0.219E+00	0.194E+00	0.159E+00	0.101E+00	0.438E-01	0.233E-0[illegible]
-0.740E-01	-0.104E+00	-0.116E+00	-0.110E+00	-0.109E+00	-0.110E+00	-0.109E+0[illegible]
-0.108E+00	-0.102E+00	-0.114E+00	-0.135E+00	-0.162E+00	-0.182E+00	-0.179E+0[illegible]
-0.157E+00	-0.122E+00	-0.795E-01	-0.448E-01	-0.197E-01	-0.440E-02	0.765E-0[illegible]
0.365E-02	-0.587E-02	-0.177E-01	-0.265E-01	-0.302E-01	-0.216E-01	-0.118E-0[illegible]
0.221E-01	0.454E-01	0.585E-01	0.607E-01	0.559E-01	0.465E-01	0.276E 0[illegible]
0.228E-01	0.228E-01	0.380E-01	0.629E-01	0.899E-01	0.112E+00	0.113E+0[illegible]
0.102E+00	0.930E-01	0.970E-01	0.118E+00	0.165E+00	0.204E+00	0.228E+00
0.227E+00	0.211E+00	0.180E+00	0.158E+00	0.134E+00	0.113E+00	0.951E-0[illegible]
0.818E-01	0.592E-01	0.411E-01	0.961E-04	-0.507E-01	-0.119E+00	-0.180E+0[illegible]
-0.233E+00	-0.267E+00	-0.291E+00	-0.297E+00	-0.295E+00	-0.290E+00	-0.298E+0[illegible]
-0.305E+00	-0.309E+00	-0.309E+00	-0.276E+00	-0.218E+00	-0.148E+00	-0.808E-0[illegible]
-0.167E-01	0.411E-01	0.824E-01	0.129E+00	0.172E+00	0.193E+00	0.202E+0[illegible]
0.192E+00	0.157E+00	0.134E+00	0.945E-01	0.746E-01	0.530E-01	0.214E-0[illegible]
-0.894E-02	-0.422E-01	-0.799E-01	-0.972E-01	-0.121E+00	-0.136E+00	-0.152E+00
-0.167E+00	-0.150E+00	-0.123E+00	-0.666E-01	-0.181E-01	0.386E-01	0.806E-01
0.133E+00	0.185E+00	0.220E+00	0.249E+00	0.245E+00	0.235E+00	0.208E+00
0.195E+00	0.176E+00	0.168E+00	0.147E+00	0.130E+00	0.100E+00	0.815E-01
0.626E-01	0.675E-01	0.786E-01	0.110E+00	0.143E+00	0.192E+00	0.225E+00
0.254E+00	0.260E+00	0.264E+00	0.252E+00	0.241E+00	0.209E+00	0.156E+00
0.957E-01	0.159E-01	-0.445E-01	-0.999E-01	-0.124E+00	-0.132E+00	-0.111E+00
-0.586E-01	-0.485E-02	0.658E-01	0.121E+00	0.170E+00	0.212E+00	0.223E+00
0.214E+00	0.170E+00	0.120E+00	0.747E-01	0.477E-01	0.428E-01	0.251E-01
-0.200E-02	-0.571E-01	-0.113E+00	-0.140E+00	-0.143E+00	-0.112E+00	-0.622E-01
-0.236E-01	0.604E-04	0.269E-01	0.449E-01	0.724E-01	0.111E+00	0.141E+00
0.161E+00	0.175E+00	0.168E+00	0.153E+00	0.143E+00	0.125E+00	0.109E+00
0.999E-01	0.870E-01	0.741E-01	0.766E-01	0.673E-01	0.592E-01	0.482E-01
0.235E-01	-0.930E-02	-0.337E-01	-0.645E-01	-0.881E-01	-0.967E-01	-0.985E-01
-0.948E-01	-0.916E-01	-0.794E-01	-0.742E-01	-0.650E-01	-0.606E-01	-0.542E-01
-0.644E-01	-0.793E-01	-0.825E-01	-0.818E-01	-0.681E-01	-0.446E-01	-0.121E 01
0.505E-02	0.107E-01	0.668E-02	0.578E-02	0.562E-02	0.157E-01	0.265E-01
0.425E-01	0.453E-01	0.458E-01	0.479E-01	0.557E-01	0.546E-01	0.469E-01
0.293E-01	0.158E-01	0.680E-02	0.907E-02	0.166E-01	0.370E-01	0.550E-01
0.818E-01	0.117E+00	0.150E+00	0.182E+00	0.188E+00	0.183E+00	0.169E+00
0.148E+00	0.135E+00	0.114E+00	0.935E-01	0.726E-01	0.470E-01	0.301E-01
0.419E-02	-0.142E-01	-0.337E-01	-0.535E-01	-0.660E-01	-0.785E-01	-0.773E-01
-0.654E-01	-0.480E-01	-0.301E-01	-0.237E-01	-0.235E-01	-0.174E-01	-0.970E-02
-0.493E-03	0.113E-01	0.470E-02	-0.108E-01	-0.262E-01	-0.449E-01	-0.504E-01
-0.600E-01	-0.680E-01	-0.782E-01	-0.986E-01	-0.119E+00	-0.125E+00	-0.127E+00
-0.112E+00	-0.840E-01	-0.543E-01	-0.156E-01	0.314E-01	0.779E-01	0.122E+00
0.158E+00	0.175E+00	0.175E+00	0.174E+00	0.166E+00	0.161E+00	0.155E+00
0.148E+00	0.136E+00	0.115E+00	0.860E-01	0.693E-01	0.469E-01	[illegible]
0.121E-03	-0.281E-01	-0.495E-01	-0.594E-01	-0.614E-01	-0.539E 01	[illegible]

-0.797E-01	-0.106E+00	-0.142E+00	-0.176E+00	-0.203E+00	-0.215E+00	-0.228E+00
-0.223E+00	-0.217E+00	-0.204E+00	-0.181E+00	-0.152E+00	-0.122E+00	-0.898E-01
-0.725E-01	-0.593E-01	-0.614E-01	-0.658E-01	-0.777E-01	-0.865E-01	-0.975E-01
-0.110E+00	-0.119E+00	-0.135E+00	-0.143E+00	-0.144E+00	-0.135E+00	-0.123E+00
-0.125E+00	-0.142E+00	-0.180E+00	-0.209E+00	-0.237E+00	-0.245E+00	-0.241E+00
-0.232E+00	-0.228E+00	-0.224E+00	-0.224E+00	-0.212E+00	-0.200E+00	-0.177E+00
-0.164E+00	-0.157E+00	-0.147E+00	-0.127E+00	-0.105E+00	-0.697E-01	-0.322E-01
-0.176E-02	0.290E-01	0.470E-01	0.576E-01	0.707E-01	0.723E-01	0.703E 01
0.666E-01	0.591E-01	0.491E-01	0.398E-01	0.303E-01	0.179E-01	0.403E-02
-0.173E-01	-0.391E-01	-0.481E-01	-0.510E-01	-0.410E-01	-0.180E-01	0.577E-02
0.199E-01	0.306E-01	0.390E-01	0.458E-01	0.525E-01	0.589E-01	0.611E-01
0.480E-01	0.360E-01	0.725E-02	-0.136E-01	-0.202E-01	-0.225E-01	-0.106E-01
-0.553E-02	-0.696E-02	-0.227E-01	-0.378E-01	-0.485E-01	-0.527E-01	-0.485E-01
-0.413E-01	-0.369E-01	-0.328E-01	-0.267E-01	-0.344E-01	-0.491E-01	-0.694E-01
-0.105E+00	-0.134E+00	-0.153E+00	-0.153E+00	-0.136E+00	-0.107E+00	-0.790E-01
-0.493E-01	-0.335E-01	-0.123E-01	0.598E-02	0.323E-01	0.705E-01	0.994E-01
0.123E+00	0.136E+00	0.134E+00	0.122E+00	0.109E+00	0.927E-01	0.790E-01
0.587E-01	0.405E-01	0.302E-01	0.226E-01	0.157E-01	0.127E-01	0.208E-02
-0.105E-01	-0.252E-01	-0.352E-01	-0.393E-01	-0.410E-01	-0.332E-01	-0.213E-01
-0.973E-02	0.322E-02	0.474E-02	-0.148E-02	-0.920E-02	-0.182E-01	-0.243E-01
-0.268E-01	-0.225E-01	-0.178E-01	-0.113E-01	-0.794E-02	-0.105E-01	-0.185E-01
-0.284E-01	-0.350E-01	-0.357E-01	-0.271E-01	0.620E-02	0.155E-01	0.350E-01
0.555E-01	0.663E-01	0.762E-01	0.723E-01	0.627E-01	0.462E-01	0.268E-01
0.145E-01	0.124E-02	-0.525E-02	-0.230E-01	-0.395E-01	-0.635E-01	-0.877E-01
-0.115E+00	-0.135E+00	-0.152E+00	-0.171E+00	-0.190E+00	-0.216E+00	-0.244E+00
-0.267E+00	-0.276E+00	-0.257E+00	-0.227E+00	-0.189E+00	-0.141E+00	-0.997E-01
-0.552E-01	-0.143E-01	0.313E-01	0.757E-01	0.123E+00	0.169E+00	0.206E+00
0.231E+00	0.239E+00	0.230E+00	0.214E+00	0.191E+00	0.163E+00	0.128E+00
0.974E-01	0.698E-01	0.493E-01	0.329E-01	0.246E-01	0.152E-01	0.589E-02
-0.887E-02	-0.291E-01	-0.696E-01	-0.125E+00	-0.186E+00	-0.238E+00	-0.265E+00
0.256E+00	-0.227E+00	-0.180E+00	-0.136E+00	-0.877E-01	-0.452E-01	-0.158E-02
0.383E-01	0.718E-01	0.930E-01	0.103E+00	0.110E+00	0.117E+00	0.127E+00
0.141E+00	0.154E+00	0.166E+00	0.170E+00	0.170E+00	0.161E+00	0.143E+00
0.124E+00	0.107E+00	0.887E-01	0.746E-01	0.647E-01	0.480E-01	0.355E-01
0.175E-01	0.672E-02	-0.226E-02	-0.100E-02	0.904E-02	0.192E-01	0.357E-01
0.471E-01	0.605E-01	0.732E-01	0.881E-01	0.902E-01	0.926E-01	0.856E-01
0.789E-01	0.695E-01	0.594E-01	0.461E-01	0.337E-01	0.228E-01	0.149E-01
0.932E-02	0.157E-01	0.157E-01	0.170E-01	0.155E-01	0.765E-03	-0.200E-01
-0.514E-01	-0.863E-01	-0.125E+00	-0.158E+00	-0.193E+00	-0.219E+00	-0.242E+00
-0.258E+00	-0.266E+00	-0.265E+00	-0.253E+00	-0.235E+00	-0.217E+00	-0.195E+00
-0.168E+00	-0.134E+00	-0.872E-01	-0.353E-01	0.155E-01	0.584E-01	0.936E-01
0.122E+00	0.145E+00	0.160E+00	0.171E+00	0.180E+00	0.185E+00	0.188E+00
0.192E+00	0.194E+00	0.191E+00	0.178E+00	0.157E+00	0.124E+00	0.843E-01
0.446E-01	0.617E-02	-0.290E-01	-0.632E-01	-0.958E-01	-0.119E+00	-0.125E+00
-0.116E+00	-0.993E-01	-0.744E-01	-0.569E-01	-0.486E-01	-0.518E-01	-0.644E-01
-0.766E-01	-0.830E-01	-0.698E-01	-0.493E-01	-0.192E-01	0.102E-01	0.373E-01
0.612E-01	0.882E-01	0.113E+00	0.130E+00	0.142E+00	0.140E+00	0.134E+00
0.120E+00	0.105E+00	0.839E-01	0.588E-01	0.392E-01	0.873E-02	-0.210E-01
-0.503E-01	-0.842E-01	-0.117E+00	-0.151E+00	-0.178E+00	-0.198E+00	-0.202E+00
-0.189E+00	-0.170E+00	-0.142E+00	-0.116E+00	-0.853E-01	-0.468E-01	-0.508E-02
0.408E-01	0.791E-01	0.112E+00	0.132E+00	0.145E+00	0.152E+00	0.157E+00
0.163E+00	0.165E+00	0.164E+00	0.156E+00	0.143E+00	0.124E+00	0.101E+00
0.736E-01	0.418E-01	0.978E-02	-0.197E-01	-0.403E-01	-0.600E-01	-0.742E-01
-0.852E-01	-0.948E-01	-0.102E+00	-0.105E+00	-0.106E+00	-0.992E-01	-0.812E-01
-0.603E-01	-0.394E-01	-0.195E-01	-0.920E-02	0.246E-02	0.999E-02	0.227E-01
0.365E-01	0.509E-01	0.648E-01	0.706E-01	0.698E-01	0.668E-01	0.609E 01
0.616E-01	0.677E-01	0.746E-01	0.794E-01	0.774E-01	0.693E-01	0.560E 01

0.144E+00	0.142E+00	0.136E+00	0.123E+00	0.111E+00	0.968E-01	0.807E-01
0.627E-01	0.353E-01	0.181E-02	-0.329E-01	-0.624E-01	-0.745E-01	-0.687E-01
-0.500E-01	-0.260E-01	-0.110E-02	0.248E-01	0.510E-01	0.778E-01	0.965E-01
0.109E+00	0.112E+00	0.105E+00	0.951E-01	0.797E-01	0.668E-01	0.540E-01
0.466E-01	0.375E-01	0.318E-01	0.239E-01	0.163E-01	0.111E-01	0.105E-01
0.109E-01	0.195E-01	0.300E-01	0.440E-01	0.609E-01	0.767E-01	0.909E-01
0.103E+00	0.109E+00	0.113E+00	0.115E+00	0.119E+00	0.129E+00	0.142E+00
0.157E+00	0.172E+00	0.185E+00	0.191E+00	0.192E+00	0.180E+00	0.159E+00
0.126E+00	0.854E-01	0.390E-01	-0.525E-02	-0.463E-01	-0.818E-01	-0.106E+00
-0.123E+00	-0.133E+00	-0.134E+00	-0.132E+00	-0.126E+00	-0.120E+00	-0.119E+00
-0.122E+00	-0.123E+00	-0.117E+00	-0.942E-01	-0.583E-01	-0.113E-01	0.365E-01
0.783E-01	0.110E+00	0.130E+00	0.141E+00	0.146E+00	0.144E+00	0.134E+00
0.120E+00	0.100E+00	0.795E-01	0.630E-01	0.453E-01	0.287E-01	0.105E-01
-0.575E-02	-0.205E-01	-0.329E-01	-0.448E-01	-0.567E-01	-0.646E-01	-0.762E-01
-0.815E-01	-0.843E-01	-0.817E-01	-0.760E-01	-0.668E-01	-0.550E-01	-0.408E-01
-0.225E-01	-0.145E-02	0.242E-01	0.478E-01	0.690E-01	0.820E-01	0.914E-01
0.955E-01	0.950E-01	0.919E-01	0.821E-01	0.677E-01	0.483E-01	0.280E-01
0.622E-02	-0.125E-01	-0.280E-01	-0.370E-01	-0.419E-01	-0.390E-01	-0.313E-01
-0.248E-01	-0.186E-01	-0.194E-01	-0.219E-01	-0.227E-01	-0.253E-01	-0.223E-01
-0.229E-01	-0.238E-01	-0.318E-01	-0.404E-01	-0.466E-01	-0.493E-01	-0.437E-01
-0.343E-01	-0.180E-01	0.501E-02	0.255E-01	0.433E-01	0.582E-01	0.707E-01
0.803E-01	0.917E-01	0.101E+00	0.106E+00	0.112E+00	0.113E+00	0.113E+00
0.112E+00	0.108E+00	0.101E+00	0.899E-01	0.748E-01	0.562E-01	0.285E-01
-0.343E-02	-0.368E-01	-0.700E-01	-0.102E+00	-0.133E+00	-0.157E+00	-0.176E+00
-0.185E+00	-0.185E+00	-0.181E+00	-0.167E+00	-0.146E+00	-0.117E+00	-0.838E-01
-0.520E-01	-0.232E-01	-0.153E-02	0.168E-01	0.277E-01	0.398E-01	0.475E-01
0.535E-01	0.530E-01	0.482E-01	0.413E-01	0.337E-01	0.307E-01	0.309E-01
0.345E-01	0.322E-01	0.281E-01	0.158E-01	0.191E-02	-0.187E-01	-0.375E-01
-0.563E-01	-0.724E-01	-0.831E-01	-0.863E-01	-0.840E-01	-0.750E-01	-0.610E-01
-0.473E-01	-0.299E-01	-0.153E-01	0.477E-03	0.108E-01	0.222E-01	0.291E-01
0.339E-01	0.378E-01	0.425E-01	0.454E-01	0.461E-01	0.416E-01	0.338E-01
0.235E-01	0.978E-02	-0.858E-03	-0.169E-01	-0.359E-01	-0.574E-01	-0.810E-01
-0.104E+00	-0.117E+00	-0.125E+00	-0.125E+00	-0.126E+00	-0.127E+00	-0.126E+00
-0.120E+00	-0.105E+00	-0.840E-01	-0.569E-01	-0.319E-01	-0.997E-02	0.118E-01

Appendix II

Simulated earthquake generated by Professor Khattri, vertical component
Acceleration in m/s2, sampled at 0.02 sec, total ordinates 6496
peak ground acceleration (PGA) value = 8.[illegible]4908 m/sec

0.000E+01	-0.794E-05	-0.109E-04	-0.114E-04	-0.137E-04	-0.314E-04	-0.285E-04
-0.421E-05	0.173E-04	0.342E-05	-0.315E-04	-0.269E-04	0.298E-04	0.347E-04
-0.353E-04	-0.786E-04	-0.311E-04	0.299E-04	0.854E-05	-0.687E-04	-0.118E-03
-0.101E-03	-0.266E-04	0.294E-04	-0.447E-05	-0.666E-04	-0.365E-04	-0.105E-04
-0.507E-04	-0.897E-04	-0.433E-04	0.818E-04	0.114E-03	0.447E-05	-0.104E-03
-0.145E-03	-0.781E-04	0.195E-04	-0.108E-04	-0.740E-04	0.274E-06	0.162E-03
0.194E-03	-0.115E-04	-0.224E-03	-0.234E-03	-0.464E-04	0.808E-04	0.345E-04
-0.481E 04	-0.366E-04	-0.345E 04	-0.143E-03	-0.261E-03	-0.239E-03	-0.701E-04
0 102E-03	0.138E-03	-0.636E-04	-0.293E-03	-0.348E-03	-0.225E-03	0.396E-04
0.214E-03	0.173E-03	-0.320E-04	-0.224E-03	-0.203E-03	-0.148E-03	-0.219E-03
-0.299E-03	-0.106E-03	0.270E-03	0.398E-03	0.357E-04	-0.528E-03	-0.733E-03
-0.532E-03	-0.118E-03	0.285E-04	-0.544E-04	-0.620E-04	0.870E-04	0.129E-03
-0.135E-03	-0.478E-03	-0.447E-03	0.547E-04	0.503E-03	0.461E-03	-0.149E-03
-0.764E-03	-0.816E-03	-0.309E-03	0.171E-03	0.246E-03	0.147E-03	0.113E-03
0.816E-04	-0.115E-03	-0.389E-03	-0.520E-03	-0.242E-03	0.258E-03	0.527E-03
0.313E-03	-0.197E-03	-0.434E-03	-0.226E-03	-0.208E-04	-0.111E-03	-0.160E-03
0.111E-03	0.372E-03	0.113E-03	-0.518E-03	-0.795E-03	-0.314E-03	0.408E-03
0.540E-03	0.449E-04	-0.392E-03	-0.354E-03	-0.133E-03	-0.954E-04	0.275E-04
-0.126E-03	0.119E-03	0.566E-03	0.375E-03	-0.351E-03	-0.989E-03	-0.692E-03
0.310E-03	0.790E-03	0.415E-03	-0.758E-04	0.221E-03	-0.232E-03	-0.299E-03
0.279E-03	0.169E-02	0.166E-02	-0.839E-04	-0.907E-03	-0.266E-03	0.454E-03
-0.177E-03	-0.133E-02	-0.118E-02	0.691E-03	0.198E-02	0.323E-03	-0.247E-02
-0 300E-02	-0.715E-03	0.165E-02	0.150E-02	-0.236E-03	-0.584E-03	0.141E-02
0.193E-02	-0.102E-02	-0.393E-02	-0.253E-02	0.204E-02	0.385E-02	0.749E-03
-0.343E-02	-0.329E-02	0.674E-03	0.245E-02	-0.423E-03	-0.332E-02	-0.170E-02
0.216E-02	0.304E-02	-0.984E-05	-0.351E-02	0.288E-02	0.116E-02	0.358E 02
0.125E-02	-0.257E-02	-0.289E-02	0.589E-05	0.144E-02	-0.647E-03	-0.305E 02
-0.174E-02	0.251E-02	0.459E-02	0.122E-02	-0.439E-02	-0.546E-02	-0.328E 03
0.430E-02	0.242E-02	-0.306E-02	-0.452E-02	-0.298E-03	0.321E-02	0.743E-03
0.416E-02	-0.424E-02	0.121E-02	0.501E-02	0.140E-02	-0.489E-02	-0.542E-02
0.411E-03	0.495E-02	0.241E-02	-0.335E-02	-0.379E-02	0.188E-02	0.458E-02
-0.911E-03	-0.785E-02	-0.710E-02	-0.264E-03	0.187E-02	-0.536E-02	-0.136E 01
-0.122E-01	-0.292E-02	0.268E-02	-0.216E-02	-0.100E-01	-0.952E-02	-0.793E-03
0.373E-02	-0.279E-02	-0.120E-01	-0.127E-01	-0.675E-02	-0.619E-02	-0.152E-01
-0.244E-01	-0.227E-01	-0.133E-01	-0.995E-02	-0.172E-01	-0.247E-01	-0.207E-01
-0.862E-02	-0.260E-02	-0.735E-02	-0.118E-01	-0.513E-02	0.848E-02	0.142E-01
0.625E-02	-0.284E-02	0.739E-03	0.137E-01	0.200E-01	0.125E-01	0.275E-02
0.432E-02	0.130E-01	0.136E-01	0.576E-03	-0.120E-01	-0.829E-02	0.869E-02
0.213E-01	0.201E-01	0.147E-01	0.181E-01	0.264E-01	0.240E-01	0.629E 02
-0.130E-01	-0.188E-01	-0.144E-01	-0.163E-01	-0.312E-01	-0.468E-01	-0.486E-01
-0.397E-01	-0.346E-01	-0.380E-01	-0.379E-01	-0.221E-01	0.184E-02	0.115E 01
-0.296E-02	-0.277E-01	-0.440E-01	-0.509E-01	-0.600E-01	-0.731E-01	-0.780E-01
-0.653E-01	-0.441E-01	-0.313E-01	-0.298E-01	-0.239E-01	-0.414E-03	0.288E-01
0.460E-01	0.493E-01	0.522E-01	0.630E-01	0.737E-01	0.712E-01	0.558E-01
0.411E-01	0.315E-01	0.125E-01	-0.263E-01	-0.687E-01	-0.812E-01	-0.503E-01
0.165E-02	0.398E-01	0.530E-01	0.555E-01	0.586E-01	0.543E-01	0.341E-01
0.148E-01	0.300E-01	0.929E-01	0.173E+00	0.224E+00	0.224E+00	0.191E+00
0.146E+00	0.892E-01	0.117E-01	-0.745E-01	-0.138E+00	-0.157E+00	-0.141E+00
-0.117E+00	-0.916E-01	-0.504E-01	0.152E-01	0.843E-01	0.121E+00	0.113E+00
0.781E-01	0.364E-01	-0.867E-02	-0.621E-01	-0.112E+00	-0.134E+00	-0.118E+00
-0.840E-01	-0.616E-01	-0.571E-01	-0.542E-01	-0.434E-01	-0.371E-01	-0.501E-01
-0.717E-01	-0.719E-01	-0.349E-01	0.194E-01	0.571E-01	0.671E-01	0.674E-01
0.719E-01	0.706E-01	0.454E-01	0.181E-02	-0.323E-01	-0.392E-01	-0.324E-01

-0.379E-01	-0.585E-01	-0.712E-01	-0.582E-01	-0.297E-01	-0.795E-02	0.538E-02
0.305E-01	0.731E-01	0.106E+00	0.970E-01	0.504E-01	0.495E-03	-0.290E-01
-0.481E-01	-0.767E-01	-0.108E+00	-0.112E+00	-0.769E-01	-0.334E-01	-0.185E-01
-0.330E-01	-0.424E-01	-0.237E-01	0.577E-02	0.173E-01	0.132E-01	0.293E-01
0.910E-01	0.179E+00	0.248E+00	0.272E+00	0.257E+00	0.218E+00	0.150E+00
0.453E-01	-0.783E-01	-0.182E+00	-0.238E+00	-0.251E+00	-0.240E+00	-0.207E+00
-0.140E+00	-0.431E-01	0.450E-01	0.839E-01	0.661E-01	0.171E-01	-0.366E-01
-0.862E-01	-0.126E+00	-0.135E+00	-0.926E-01	-0.145E-01	0.465E-01	0.489E-01
0.272E-02	-0.501E-01	-0.831E-01	-0.108E+00	-0.143E+00	-0.170E+00	-0.157E+00
-0.878E-01	0.156E-01	0.119E+00	0.208E+00	0.284E+00	0.338E+00	0.344E+00
0.290E+00	0.203E+00	0.126E+00	0.736E-01	0.215E-01	-0.534E-01	-0.129E+00
-0.156E+00	-0.111E+00	-0.220E-01	0.614E-01	0.122E+00	0.175E+00	0.226E+00
0.250E+00	0.219E+00	0.138E+00	0.454E-01	-0.239E-01	-0.670E-01	-0.954E-01
-0.108E+00	-0.945E-01	-0.626E-01	-0.457E-01	-0.700E-01	-0.120E+00	-0.155E+00
-0.150E+00	-0.118E+00	-0.807E-01	-0.423E-01	0.813E-02	0.617E-01	0.854E-01
0.589E-01	0.371E-02	-0.366E-01	-0.415E-01	-0.320E-01	-0.357E-01	-0.557E-01
-0.778E-01	-0.993E-01	-0.131E+00	-0.167E+00	-0.173E+00	-0.126E+00	-0.491E-01
0.461E-02	0.891E-02	-0.789E-02	-0.437E-02	0.179E-01	0.247E-01	0.310E-02
-0.126E-01	0.102E-01	0.440E-01	0.261E-01	-0.582E-01	-0.139E+00	-0.136E+00
-0.514E-01	0.273E-01	0.336E-01	-0.656E-02	-0.228E-01	-0.156E-02	-0.259E-02
-0.668E-01	-0.142E+00	-0.136E+00	-0.283E-01	0.914E-01	0.131E+00	0.103E+00
0.100E+00	0.170E+00	0.255E+00	0.261E+00	0.171E+00	0.517E-01	-0.343E-01
-0.966E-01	-0.169E+00	-0.231E+00	-0.212E+00	-0.878E-01	0.724E-01	0.167E+00
0.169E+00	0.133E+00	0.117E+00	0.109E+00	0.696E-01	0.162E-02	-0.375E-01
-0.105E-01	0.518E-01	0.943E-01	0.107E+00	0.118E+00	0.126E+00	0.786E-01
-0.568E-01	-0.213E+00	-0.270E+00	-0.180E+00	-0.225E-01	0.755E-01	0.729E-01
0.276E-01	-0.368E-03	-0.230E 01	-0.769E-01	-0.140E+00	-0.139E+00	-0 451E-01
0.722E-01	0.116E+00	0.694E-01	-0.359E-02	-0.543E-01	-0.106E+00	-0 190E+00
-0.257E+00	-0.209E+00	-0.256E-01	0.175E+00	0.250E+00	0.179E+00	0.707E-01
0.151E-01	-0.730E-02	-0.640E-01	-0.141E+00	-0.141E+00	-0.240E-01	0.117E+00
0.154E+00	0.803E-01	0.186E-01	0.438E-01	0.668E-01	-0.516E-01	-0.290E+00
-0.437E+00	-0.318E+00	-0 713E-02	0.238E+00	0.259E+00	0.167E+00	0.191E+00
0.395E+00	0.591E+00	0.559E+00	0.280E+00	-0.497E-01	-0.228E+00	-0.210E+00
-0.750E-01	0.107E+00	0.315E+00	0.507E+00	0.589E+00	0.480E+00	0.203E+00
-0.125E+00	-0.376E+00	-0.480E+00	-0.404E+00	-0.155E+00	0.181E+00	0.414E+00
0.360E+00	0.294E-01	-0.328E+00	-0.419E+00	-0.185E+00	0.135E+00	0.238E+00
0.429E-01	-0.260E+00	-0.432E+00	-0.406E+00	-0.291E+00	-0.199E+00	-0.115E+00
0.345E-01	0.250E+00	0.419E+00	0.411E+00	0.198E+00	-0.127E+00	-0.417E+00
-0.551E+00	-0.492E+00	-0.304E+00	-0.124E+00	-0.772E-01	-0.170E+00	-0.266E+00
-0.188E+00	0.999E-01	0.431E+00	0.549E+00	0.324E+00	-0.121E+00	-0.486E+00
-0.526E+00	-0.221E+00	0.209E+00	0.474E+00	0.414E+00	0.994E-01	-0.243E+00
-0.408E+00	-0.355E+00	-0.206E+00	-0.113E+00	-0.129E+00	-0.212E+00	-0.304E+00
-0.381E+00	-0.424E+00	-0.370E+00	-0.152E+00	0.184E+00	0.454E+00	0.461E+00
0.177E+00	-0.209E+00	-0.447E+00	-0.419E+00	-0.197E+00	0.816E-01	0.333E+00
0.533E+00	0.639E+00	0.576E+00	0.313E+00	-0.554E-01	-0.370E+00	-0.519E+00
-0.508E+00	-0.410E+00	-0.279E+00	-0.135E+00	-0.259E-02	0.763E-01	0.848E-01
0.595E-01	0.470E-01	0.362E-01	-0.258E-01	-0.138E+00	-0.203E+00	-0.106E+00
0.131E+00	0.319E+00	0.278E+00	0.132E-01	-0.257E+00	-0.320E+00	-0.177E+00
-0.314E-01	-0.627E-01	-0.228E+00	-0.303E+00	-0.121E+00	0.232E+00	0.492E+00
0.452E+00	0.152E+00	-0.178E+00	-0.342E+00	-0.313E+00	-0.203E+00	-0.107E+00
-0.364E-01	0.954E-02	-0.297E 01	-0.219E+00	-0.501E+00	-0.665E+00	-0.516E+00
-0.836E-01	0.374E+00	0.587E+00	0.504E+00	0.290E+00	0.106E+00	-0.565E-01
-0.292E+00	-0.595E+00	-0.798E+00	-0.732E+00	-0.419E+00	-0.479E-01	0.185E+00
0.211E+00	0.482E-01	-0.264E+00	-0.645E+00	-0.895E+00	-0.792E+00	-0.310E+00
0.265E+00	0.578E+00	0.556E+00	0.465E+00	0.570E+00	0.754E+00	0.619E+00
-0.297E-02	-0.733E+00	-0.952E+00	-0.441E+00	0.343E+00	0.727E+00	0.500E+00
0.721E-01	-0.446E-01	0.211E+00	0.446E+00	0.340E+00	0.549E-02	-0.193E+00
-0.110E+00	0.242E-01	-0.783E-01	-0.390E+00	-0.603E+00	-0.497E+00	-0.194E+00
0.143E-01	-0.269E-01	-0.192E+00	-0.288E+00	-0.276E+00	-0.272E+00	-0.358E+00
-0.451E+00	-0.397E+00	-0.148E+00	0.172E+00	0.347E+00	0.254E+00	-0.733E-01

-0.424E+00	-0.575E+00	-0.419E+00	-0.834E-01	0.171E+00	0.166E+00	-0.366E-01
-0.189E+00	-0.118E+00	0.112E+00	0.276E+00	0.234E+00	0.597E-01	-0.627E-01
-0.341E-01	0.798E-01	0.174E+00	0.183E+00	0.112E+00	-0.229E-01	-0.172E+00
-0.238E+00	-0.909E-01	0.271E+00	0.677E+00	0.895E+00	0.829E+00	0.575E+00
0.270E+00	-0.495E-01	-0.392E+00	-0.692E+00	-0.748E+00	-0.447E+00	0.882E-01
0.534E+00	0.687E+00	0.595E+00	0.472E+00	0.433E+00	0.414E+00	0.314E+00
0.149E+00	0.171E-01	-0.567E-01	-0.155E+00	-0.320E+00	-0.458E+00	-0.411E+00
-0.157E+00	0.107E+00	0.146E+00	-0.117E+00	-0.516E+00	-0.798E+00	-0.785E+00
-0.462E+00	0.466E-01	0.524E+00	0.745E+00	0.593E+00	0.146E+00	-0.373E+00
-0.742E+00	-0.872E+00	-0.761E+00	-0.438E+00	0.588E-01	0.563E+00	0.803E+00
0.576E+00	-0.354E-01	-0.700E+00	-0.112E+01	-0.125E+01	-0.122E+01	-0.116E+01
-0.996E+00	-0.687E+00	-0.319E+00	-0.541E-01	0.941E-01	0.267E+00	0.526E+00
0.663E+00	0.357E+00	-0.415E+00	-0.123E+01	-0.156E+01	-0.127E+01	-0.700E+00
-0.291E+00	-0.105E+00	0.150E+00	0.705E+00	0.141E+01	0.182E+01	0.162E+01
0.874E+00	-0.320E-01	-0.655E+00	-0.714E+00	-0.216E+00	0.559E+00	0.120E+01
0.141E+01	0.124E+01	0.985E+00	0.873E+00	0.850E+00	0.712E+00	0.432E+00
0.267E+00	0.408E+00	0.670E+00	0.624E+00	0.130E+00	-0.357E+00	-0.136E+00
0.103E+01	0.267E+01	0.411E+01	0.504E+01	0.570E+01	0.623E+01	0.634E+01
0.544E+01	0.338E+01	0.713E+00	-0.165E+01	-0.308E+01	-0.356E+01	-0.345E+01
-0.301E+01	-0.234E+01	-0.149E+01	-0.481E+00	0.630E+00	0.182E+01	0.299E+01
0.396E+01	0.457E+01	0.478E+01	0.457E+01	0.382E+01	0.224E+01	-0.248E+00
-0.316E+01	-0.554E+01	-0.655E+01	-0.609E+01	-0.483E+01	-0.361E+01	-0.279E+01
-0.223E+01	-0.157E+01	-0.675E+00	0.321E+00	0.121E+01	0.182E+01	0.200E+01
0.162E+01	0.625E+00	-0.835E+00	-0.247E+01	-0.397E+01	-0.506E+01	-0.552E+01
-0.509E+01	-0.358E+01	-0.108E+01	0.201E+01	0.505E+01	0.738E+01	0.855E+01
0.832E+01	0.669E+01	0.387E+01	0.328E+00	-0.328E+01	-0.616E+01	-0.766E+01
-0.747E+01	-0.582E+01	-0.337E+01	-0.867E+00	0.117E+01	0.258E+01	0.341E+01
0.380E+01	0.391E+01	0.403E+01	0.452E+01	0.543E+01	0.647E+01	0.703E+01
0.676E+01	0.577E+01	0.437E+01	0.264E+01	0.348E+00	-0.257E+01	-0.554E+01
-0.746E+01	-0.746E+01	-0.555E+01	-0.256E+01	0.518E+00	0.308E+01	0.490E+01
0.575E+01	0.539E+01	0.367E+01	0.959E+00	-0.208E+01	-0.474E+01	-0.657E+01
-0.728E+01	-0.670E+01	-0.487E+01	-0.224E+01	0.446E+00	0.254E+01	0.373E+01
0.407E+01	0.362E+01	0.243E+01	0.756E+00	-0.812E+00	-0.160E+01	-0.149E+01
-0.108E+01	-0.119E+01	-0.211E+01	-0.337E+01	-0.422E+01	-0.438E+01	-0.411E+01
-0.367E+01	-0.287E+01	-0.127E+01	0.117E+01	0.372E+01	0.536E+01	0.557E+01
0.467E+01	0.342E+01	0.229E+01	0.129E+01	0.281E+00	-0.686E+00	-0.134E+01
-0.158E+01	-0.160E+01	-0.157E+01	-0.135E+01	-0.623E+00	0.627E+00	0.192E+01
0.258E+01	0.236E+01	0.155E+01	-0.697E+00	0.196E-01	-0.507E+00	-0.817E+00
-0.528E+00	0.687E+00	0.266E+01	0.459E+01	0.557E+01	0.515E+01	0.343E+01
0.834E+00	-0.198E+01	-0.408E+01	-0.451E+01	-0.275E+01	0.623E+00	0.427E+01
0.691E+01	0.820E+01	0.836E+01	0.750E+01	0.519E+01	0.118E+01	-0.359E+01
-0.715E+01	-0.795E+01	-0.611E+01	-0.334E+01	-0.125E+01	-0.225E+00	0.410E+00
0.111E+01	0.144E+01	0.735E+00	-0.850E+00	-0.225E+01	-0.255E+01	-0.187E+01
-0.108E+01	-0.704E+00	-0.398E+00	0.454E+00	0.171E+01	0.246E+01	0.197E+01
0.488E+00	-0.979E+00	-0.172E+01	-0.197E+01	-0.241E+01	-0.330E+01	-0.408E+01
-0.407E+01	-0.319E+01	-0.213E+01	-0.155E+01	-0.162E+01	-0.183E+01	-0.174E+01
-0.128E+01	-0.855E+00	-0.831E+00	-0.127E+01	-0.189E+01	-0.228E+01	-0.215E+01
-0.141E+01	-0.121E+00	0.153E+01	0.324E+01	0.462E+01	0.540E+01	0.552E+01
0.514E+01	0.455E+01	0.378E+01	0.270E+01	0.122E+01	-0.418E+00	-0.173E+01
-0.242E+01	-0.261E+01	-0.278E+01	-0.317E+01	-0.354E+01	-0.336E+01	-0.236E+01
-0.832E+00	0.657E+00	0.179E+01	0.261E+01	0.326E+01	0.363E+01	0.356E+01
0.302E+01	0.233E+01	0.175E+01	0.126E+01	0.506E+00	-0.632E+00	-0.197E+01
-0.312E+01	-0.391E+01	-0.450E+01	-0.501E+01	-0.528E+01	-0.491E+01	-0.377E+01
-0.225E+01	-0.891E+00	-0.501E-01	0.445E+00	0.808E+00	0.110E+01	0.979E+00
0.210E+00	-0.113E+01	-0.256E+01	-0.354E+01	-0.385E+01	-0.364E+01	-0.313E+01
-0.244E+01	-0.159E+01	-0.672E+00	0.865E-01	0.456E+00	0.343E+00	0.523E+01
-0.183E+00	-0.297E+00	-0.521E+00	-0.102E+01	-0.166E+01	-0.195E+01	-0.166E+01
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

-0.288E+01	-0.358E+01	-0.300E+01	-0.179E+01	-0.801E+00	-0.321E+00	-0.606E-01
0.313E+00	0.838E+00	0.115E+01	0.836E+00	-0.345E-01	-0.113E+01	-0.204E+01
-0.262E+01	-0.307E+01	-0.350E+01	-0.373E+01	-0.348E+01	-0.267E+01	-0.174E+01
-0.123E+01	-0.144E+01	-0.213E+01	-0.288E+01	-0.341E+01	-0.370E+01	-0.388E+01
-0.400E+01	-0.405E+01	-0.404E+01	-0.400E+01	-0.388E+01	-0.361E+01	-0.295E+01
-0.207E+01	-0.113E+01	-0.395E+00	0.323E-01	0.178E+00	0.125E+00	-0.401E-01
-0.825E-01	0.182E+00	0.926E+00	0.180E+01	0.238E+01	0.235E+01	0.183E+01
0.135E+01	0.116E+01	0.132E+01	0.148E+01	0.146E+01	0.145E+01	0.167E+01
0.221E+01	0.280E+01	0.304E+01	0.264E+01	0.163E+01	0.356E+00	-0.882E+00
-0.169E+01	-0.199E+01	-0.179E+01	-0.112E+01	-0.119E+00	0.105E+01	0.219E+01
0.311E+01	0.363E+01	0.369E+01	0.320E+01	0.222E+01	0.817E+00	-0.630E+00
-0.178E+01	-0.232E+01	-0.233E+01	-0.211E+01	-0.205E+01	-0.215E+01	-0.221E+01
-0.210E+01	-0.175E+01	-0.126E+01	-0.663E+00	0.144E-01	0.720E+00	0.116E+01
0.111E+01	0.466E+00	-0.561E+00	-0.168E+01	-0.271E+01	-0.348E+01	-0.381E+01
-0.343E+01	-0.232E+01	-0.746E+00	0.654E+00	0.143E+01	0.137E+01	0.697E+00
-0.259E+00	-0.120E+01	-0.190E+01	-0.225E+01	-0.233E+01	-0.222E+01	-0.191E+01
-0.137E+01	-0.416E+00	0.694E+00	0.152E+01	0.160E+01	0.105E+01	0.432E+00
0.292E+00	0.733E+00	0.134E+01	0.162E+01	0.156E+01	0.142E+01	0.145E+01
0.158E+01	0.147E+01	0.100E+01	0.340E+00	-0.274E+00	-0.757E+00	-0.102E+01
-0.119E+01	-0.119E+01	-0.102E+01	-0.817E+00	-0.771E+00	-0.962E+00	-0.136E+01
-0.172E+01	-0.185E+01	-0.170E+01	-0.129E+01	-0.716E+00	-0.626E-01	0.686E+00
0.160E+01	0.264E+01	0.358E+01	0.409E+01	0.396E+01	0.324E+01	0.217E+01
0.896E+00	-0.615E+00	-0.235E+01	-0.393E+01	-0.475E+01	-0.442E+01	-0.312E+01
-0.158E+01	-0.357E+00	0.267E+00	0.442E+00	0.299E+00	-0.105E+00	-0.635E+00
-0.923E+00	-0.697E+00	-0.670E-01	0.596E+00	0.108E+01	0.162E+01	0.271E+01
0.426E+01	0.563E+01	0.613E+01	0.572E+01	0.508E+01	0.468E+01	0.420E+01
0.275E+01	0.265E-01	-0.314E+01	-0.517E+01	-0.499E+01	-0.302E+01	-0.517E+00
0.130E+01	0.220E+01	0.274E+01	0.341E+01	0.401E+01	0.402E+01	0.303E+01
0.135E+01	-0.352E+00	-0.146E+01	-0.192E+01	-0.196E+01	-0.186E+01	-0.165E+01
-0.116E+01	-0.386E+00	0.474E+00	0.106E+01	0.120E+01	0.940E+00	0.406E+00
-0.270E+00	-0.101E+01	-0.165E+01	-0.201E+01	-0.198E+01	-0.167E+01	-0.128E+01
-0.965E+00	-0.723E+00	-0.588E+00	-0.708E+00	-0.131E+01	-0.229E+01	-0.327E+01
-0.365E+01	-0.329E+01	-0.247E+01	-0.169E+01	-0.123E+01	-0.963E+00	-0.673E+00
-0.326E+00	-0.125E+00	-0.179E+00	-0.406E+00	-0.497E+00	-0.233E+00	0.347E+00
0.101E+01	0.151E+01	0.170E+01	0.161E+01	0.137E+01	0.118E+01	0.115E+01
0.130E+01	0.153E+01	0.167E+01	0.151E+01	0.101E+01	0.255E+00	-0.383E+00
-0.479E+00	0.193E+00	0.138E+01	0.254E+01	0.313E+01	0.299E+01	0.250E+01
0.207E+01	0.192E+01	0.188E+01	0.178E+01	0.159E+01	0.145E+01	0.136E+01
0.112E+01	0.500E+00	-0.385E+00	-0.120E+01	-0.154E+01	-0.125E+01	-0.450E+00
0.570E+00	0.150E+01	0.207E+01	0.207E+01	0.156E+01	0.787E+00	0.172E+00
-0.909E-01	-0.119E+00	-0.211E+00	-0.488E+00	-0.848E+00	-0.104E+01	-0.103E+01
-0.877E+00	-0.708E+00	-0.510E+00	-0.251E+00	0.445E-01	0.198E+00	0.127E+00
-0.108E+00	-0.331E+00	-0.427E+00	-0.395E+00	-0.337E+00	-0.301E+00	-0.323E+00
-0.306E+00	-0.284E+00	-0.251E+00	-0.187E+00	-0.258E-01	0.299E+00	0.727E+00
0.117E+01	0.151E+01	0.182E+01	0.219E+01	0.262E+01	0.296E+01	0.287E+01
0.210E+01	0.727E+00	-0.808E+00	-0.201E+01	-0.250E+01	-0.237E+01	-0.181E+01
-0.110E+01	-0.385E+00	0.215E+00	0.526E+00	0.418E+00	-0.634E-02	-0.432E+00
-0.514E+00	-0.152E+00	0.472E+00	0.960E+00	0.106E+01	0.765E+00	0.313E+00
0.525E-01	0.191E+00	0.632E+00	0.100E+01	0.904E+00	0.253E+00	-0.580E+00
-0.111E+01	-0.114E+01	-0.102E+01	-0.124E+01	-0.187E+01	-0.243E+01	-0.226E+01
-0.125E+01	0.253E-01	0.780E+00	0.707E+00	0.206E+00	-0.108E+00	0.526E-01
0.357E+00	0.314E+00	-0.260E+00	-0.104E+01	-0.150E+01	-0.139E+01	-0.871E+00
-0.361E+00	-0.158E+00	-0.251E+00	-0.373E+00	-0.249E+00	0.147E+00	0.688E+00
0.113E+01	0.128E+01	0.111E+01	0.673E+00	0.161E+00	-0.193E+00	-0.241E+00
-0.248E-01	0.175E+00	0.110E+00	-0.253E+00	-0.635E+00	-0.740E+00	-0.478E+00
-0.503E-01	0.322E+00	0.579E+00	0.865E+00	0.122E+01	0.159E+01	0.189E+01
0.213E+01	0.237E+01	0.249E+01	0.233E+01	0.186E+01	0.143E+01	0.144E+01
0.188E+01	0.216E+01	0.166E+01	0.397E+00	-0.876E+00	-0.135E+01	-0.918E+00
-0.263E+00	-0.526E-01	-0.354E+00	-0.670E+00	-0.610E+00	-0.342E+00	-0.261E+00
-0.433E+00	-0.468E+00	0.401E-02	0.830E+00	0.142E+01	0.133E+01	0.740E+00

0.255E+00	0.283E+00	0.740E+00	0.115E+01	0.109E+01	0.477E+00	-0.552E+00
-0.169E+01	-0.262E+01	-0.297E+01	-0.260E+01	-0.170E+01	-0.785E+00	-0.439E+00
-0.835E+00	-0.166E+01	-0.239E+01	-0.269E+01	-0.259E+01	-0.236E+01	-0.213E+01
-0.182E+01	-0.134E+01	-0.766E+00	-0.367E+00	-0.294E+00	-0.399E+00	-0.300E+00
0.216E+00	0.916E+00	0.129E+01	0.102E+01	0.305E+00	-0.352E+00	-0.588E+00
-0.518E+00	-0.483E+00	-0.610E+00	-0.595E+00	-0.154E+00	0.595E+00	0.106E+01
0.798E+00	0.609E-01	-0.303E+00	0.391E+00	0.191E+01	0.317E+01	0.311E+01
0.158E+01	-0.418E+00	-0.159E+01	-0.133E+01	-0.128E+00	0.975E+00	0.132E+01
0.106E+01	0.816E+00	0.942E+00	0.120E+01	0.111E+01	0.519E+00	-0.229E+00
-0.668E+00	-0.664E+00	-0.451E+00	-0.207E+00	0.101E+00	0.568E+00	0.986E+00
0.944E+00	0.278E+00	-0.582E+00	-0.960E+00	-0.611E+00	0.791E-02	0.230E+00
-0.125E+00	-0.611E+00	-0.783E+00	-0.733E+00	-0.981E+00	-0.171E+01	-0.246E+01
-0.253E+01	-0.180E+01	-0.853E+00	-0.421E+00	-0.614E+00	-0.906E+00	-0.828E+00
-0.456E+00	-0.251E+00	-0.442E+00	-0.659E+00	-0.325E+00	0.759E+00	0.211E+01
0.291E+01	0.265E+01	0.143E+01	-0.676E-01	-0.103E+01	-0.960E+00	0.373E-01
0.134E+01	0.221E+01	0.226E+01	0.164E+01	0.872E+00	0.423E+00	0.532E+00
0.112E+01	0.187E+01	0.238E+01	0.228E+01	0.149E+01	0.448E+00	-0.244E+00
-0.226E+00	0.250E+00	0.630E+00	0.641E+00	0.520E+00	0.653E+00	0.100E+01
0.109E+01	0.587E+00	-0.176E+00	-0.503E+00	-0.702E-01	0.662E+00	0.943E+00
0.513E+00	-0.985E-01	-0.212E+00	0.278E+00	0.794E+00	0.677E+00	-0.212E+00
-0.143E+01	-0.238E+01	-0.265E+01	-0.211E+01	-0.899E+00	0.594E+00	0.177E+01
0.207E+01	0.145E+01	0.337E+00	-0.643E+00	-0.122E+01	-0.153E+01	-0.182E+01
-0.210E+01	-0.221E+01	-0.211E+01	-0.198E+01	-0.200E+01	-0.209E+01	-0.193E+01
-0.136E+01	-0.544E+00	0.113E+00	0.338E+00	0.148E+00	-0.194E+00	-0.407E+00
-0.350E+00	-0.807E-01	0.226E+00	0.365E+00	0.282E+00	0.103E+00	-0.168E-01
-0.801E-01	-0.273E+00	-0.707E+00	-0.120E+01	-0.133E+01	-0.935E+00	-0.283E+00
0.170E+00	0.259E+00	0.296E+00	0.632E+00	0.119E+01	0.155E+01	0.152E+01
0.147E+01	0.197E+01	0.300E+01	0.372E+01	0.325E+01	0.169E+01	0.245E+00
0.240E+00	0.189E+01	0.404E+01	0.508E+01	0.420E+01	0.188E+01	-0.649E+00
-0.238E+01	-0.305E+01	-0.300E+01	-0.274E+01	-0.256E+01	-0.240E+01	-0.207E+01
-0.139E+01	-0.491E+00	0.310E+00	0.714E+00	0.662E+00	0.417E+00	0.261E+00
0.297E+00	0.342E+00	0.165E+00	-0.311E+00	-0.956E+00	-0.152E+01	-0.178E+01
-0.167E+01	-0.134E+01	-0.114E+01	-0.131E+01	-0.179E+01	-0.212E+01	-0.190E+01
-0.123E+01	-0.831E+00	-0.138E+01	-0.280E+01	-0.409E+01	-0.413E+01	-0.265E+01
-0.508E+00	0.106E+01	0.145E+01	0.111E+01	0.886E+00	0.117E+01	0.168E+01
0.181E+01	0.136E+01	0.559E+00	-0.132E+00	-0.467E+00	-0.434E+00	-0.139E+00
0.302E+00	0.753E+00	0.106E+01	0.111E+01	0.931E+00	0.728E+00	0.700E+00
0.907E+00	0.120E+01	0.132E+01	0.108E+01	0.488E+00	-0.173E+00	-0.560E+00
-0.512E+00	-0.248E+00	-0.129E+00	-0.334E+00	-0.605E+00	-0.516E+00	0.708E-01
0.818E+00	0.124E+01	0.119E+01	0.978E+00	0.926E+00	0.938E+00	0.555E+00
-0.485E+00	-0.193E+01	-0.319E+01	-0.382E+01	-0.383E+01	-0.343E+01	-0.269E+01
-0.159E+01	-0.262E+00	0.852E+00	0.130E+01	0.102E+01	0.298E+00	-0.458E+00
-0.108E+01	-0.155E+01	-0.181E+01	-0.176E+01	-0.135E+01	-0.684E+00	0.105E+00
0.101E+01	0.197E+01	0.267E+01	0.264E+01	0.181E+01	0.726E+00	0.175E+00
0.349E+00	0.587E+00	0.378E-01	-0.137E+01	-0.279E+01	-0.327E+01	-0.269E+01
-0.177E+01	-0.111E+01	-0.677E+00	0.882E-02	0.971E+00	0.165E+01	0.156E+01
0.976E+00	0.752E+00	0.139E+01	0.247E+01	0.307E+01	0.271E+01	0.169E+01
0.627E+00	-0.175E+00	-0.795E+00	-0.127E+01	-0.134E+01	-0.793E+00	0.175E+00
0.978E+00	0.118E+01	0.931E+00	0.774E+00	0.105E+01	0.159E+01	0.175E+01
0.107E+01	-0.446E+00	-0.219E+01	-0.332E+01	-0.328E+01	-0.221E+01	-0.830E+00
0.110E+00	0.500E+00	0.852E+00	0.163E+01	0.251E+01	0.264E+01	0.151E+01
-0.317E+00	-0.168E+01	-0.199E+01	-0.178E+01	-0.200E+01	-0.281E+01	-0.324E+01
-0.225E+01	0.120E-01	0.217E+01	0.286E+01	0.193E+01	0.439E+00	-0.518E+00
-0.659E+00	-0.455E+00	-0.378E+00	-0.481E+00	-0.607E+00	-0.713E+00	-0.906E+00
-0.115E+01	-0.120E+01	-0.868E+00	-0.209E+00	0.529E+00	0.113E+01	0.154E+01
0.170E+01	0.152E+01	0.101E+01	0.371E+00	-0.118E+00	-0.339E+00	-0.415E+00
-0.480E+00	-0.466E+00	-0.273E+00	0.862E-01	0.380E+00	0.548E+00	0.795E+00
0.138E+01	0.224E+01	0.289E+01	0.291E+01	0.238E+01	0.175E+01	0.131E+01
0.998E+00	0.603E+00	0.140E+00	-0.212E+00	-0.450E+00	-0.749E+00	-0.103E+01
-0.584E+00	0.135E+01	0.458E+01	0.756E+01	0.845E+01	0.672E+01	0.380E+01

0.188E+01	0.201E+01	0.328E+01	0.382E+01	0.250E+01	-0.179E+00	-0.283E+01
-0.436E+01	-0.457E+01	-0.380E+01	-0.235E+01	-0.370E+00	0.184E+01	0.366E+01
0.457E+01	0.448E+01	0.382E+01	0.302E+01	0.216E+01	0.994E+00	-0.594E+00
-0.227E+01	-0.345E+01	-0.385E+01	-0.374E+01	-0.372E+01	-0.410E+01	-0.455E+01
-0.447E+01	-0.361E+01	-0.234E+01	-0.131E+01	-0.858E+00	-0.796E+00	-0.775E+00
-0.769E+00	-0.106E+01	-0.178E+01	-0.260E+01	-0.302E+01	-0.285E+01	-0.245E+01
-0.224E+01	-0.215E+01	-0.175E+01	-0.796E+00	0.348E+00	0.100E+01	0.894E+00
0.433E+00	0.280E+00	0.648E+00	0.116E+01	0.134E+01	0.117E+01	0.105E+01
0.142E+01	0.234E+01	0.356E+01	0.474E+01	0.560E+01	0.591E+01	0.561E+01
0.499E+01	0.463E+01	0.497E+01	0.582E+01	0.645E+01	0.617E+01	0.492E+01
0.323E+01	0.165E+01	0.277E+00	-0.106E+01	-0.238E+01	-0.325E+01	-0.319E+01
-0.209E+01	-0.427E+00	0.112E+01	0.208E+01	0.236E+01	0.219E+01	0.187E+01
0.157E+01	0.127E+01	0.701E+00	-0.366E+00	0.188E+01	-0.335E+01	-0.420E+01
-0.420E+01	-0.373E+01	-0.328E+01	-0.302E+01	0.264E+01	-0.188E+01	-0.876E+00
0.285E+00	-0.626E+00	0.182E+01	-0.330E+01	0.441E+01	-0.486E+01	-0.477E+01
-0.438E+01	0.395E+01	0.365E+01	-0.342E+01	0.300E+01	-0.201E+01	-0.429E+00
0.124E+01	0.226E+01	0.227E+01	0.174E+01	0.157E+01	0.224E+01	0.336E+01
0.398E+01	0.344E+01	0.189E+01	0.870E 01	0.118E+01	-0.150E+01	-0.874E+00
0.342E+00	0.156E+01	0.209E+01	0.150E+01	0.814E-01	-0.141E+01	-0.204E+01
-0.164E+01	-0.689E+00	0.159E+00	0.631E+00	0.952E+00	0.143E+01	0.200E+01
0.234E+01	0.228E+01	0.200E+01	0.178E+01	0.177E+01	0.182E+01	0.169E+01
0.119E+01	0.465E+00	-0.332E+00	-0.939E+00	-0.117E+01	-0.960E+00	-0.565E+00
-0.374E+00	0.656E+00	-0.126E+01	-0.167E+01	0.149E+01	0.857E+00	-0.262E+[illegible]
-0.165E+00	0.409E+00	-0.540E+00	0.253E+00	0.259E+00	0.519E+00	0.412[illegible]
0.303E+00	0.679E+00	0.166E+01	0.270E+01	0.302E+01	0.228E+01	0.712[illegible]
-0.930E+00	0.207E+01	0.251E+01	-0.231E+01	0.180E+01	0.121E+01	[illegible]
-0.497E+00	-0.594E+00	-0.816E+00	-0.953E+00	0.893E+00	0.658E+00	-0.501[illegible]
-0.431E+00	-0.365E+00	-0.312E 01	0.484E+00	0.950E+00	0.950E+00	0.354[illegible]
-0.574E+00	-0.146E+01	0.197E+01	0.203E+01	0.162E+01	0.837E+00	0.214[illegible]
0.468E+00	0.121E+00	0.994E+00	0.223E+01	0.281E+01	0.264E+01	-0.209[illegible]
-0.188E+01	-0.221E+01	0.271E+01	0.285E+01	0.232E+01	0.148E+01	0.370[illegible]
0.700E+00	[illegible]	0.136E+01	0.361E+00	0.10[illegible]E+01	0.197E+01	-0.157E+01
-0.220E+00	[illegible]	0.100E+01	0.178E+00	0.504E+00	-0.337E+00	0.379E+00
0.566E+00	-0.251E+00	0.159E+01	-0.239E+01	-0.215E+01	-0.126E+01	-0.53[illegible]
-0.280E+00	-0.254E+00	-0.383E-01	0.432E+00	0.875E+00	0.939E+00	0.64[illegible]
0.205E+00	-0.472E-01	-0.308E 01	0.327E+00	0.981E+00	0.178E+01	0.23[illegible]
0.248E+01	0.211E+01	0.157E+01	0.120E+01	0.112E+01	0.112E+01	0.94[illegible]
0.446E+00	-0.181E+00	-0.701E+00	-0.877E+00	-0.787E+00	-0.657E+00	-0.72[illegible]
-0.101E+01	-0.132E+01	-0.131E+01	-0.828E+00	0.233E-01	0.781E+00	0.101[illegible]
0.442E-00	-0.780E+00	-0.218E+01	-0.318E+01	-0.341E+01	-0.285E+01	-0.196[illegible]
-0.121E+01	-0.797E+00	-0.567E+00	-0.244E+00	0.305E+00	0.758E+00	0.791E+00
0.199E+00	-0.703E+00	-0.152E+01	-0.193E+01	-0.200E+01	-0.205E+01	-0.232E+01
-0.276E+01	-0.319E+01	-0.325E+01	-0.286E+01	-0.213E+01	-0.134E+01	-0.745E+00
-0.253E+00	0.159E+00	0.608E+00	0.971E+00	0.110E+01	0.105E+01	0.966E+00
0.107E+01	0.116E+01	0.965E+00	0.273E+00	-0.677E+00	-0.134E+01	-0.128E+01
-0.493E+00	0.592E+00	0.155E+01	0.204E+01	0.201E+01	0.166E+01	0.122E+01
0.972E+00	0.102E+01	0.115E+01	0.102E+01	0.150E+00	-0.369E+00	-0.944E+00
-0.837E+00	0.288E 01	0.142E+01	0.295E+01	0.11[illegible]E+01	0.462E+01	0.423E+01
0.324E+01	0.229E+01	0.188E+01	0.188E+01	0.161E+01	0.676E+00	-0.595E+00
-0.134E+01	0.202E+01	0.122E+00	0.402E+00	0.511E-01	-0.732E+00	0.107E+01
-0.[illegible]92E+00	0.214E+00	0.723E+00	0.805E+00	0.864E+00	0.120E+01	0.148E+01
0.122E+01	0.281E+00	-0.819E+00	-0.141E+01	-0.126E+01	-0.696E+00	-0.228E+00
-0.750E-01	-0.275E+00	-0.729E+00	-0.127E+01	-0.171E+01	-0.169E+01	-0.121E+01
-0.615E+00	-0.479E+00	-0.992E+00	-0.191E+01	-0.268E+01	-0.304E+01	-0.314E+01
-0.318E+01	-0.311E+01	-0.266E+01	-0.166E+01	-0.254E+00	0.102E+01	0.176E+01
0.186E+01	0.149E+01	0.101E+01	0.602E+00	0.225E+00	-0.230E+00	-0.890E+00
-0.161E+01	-0.207E+01	-0.199E+01	-0.139E+01	-0.630E+00	-0.188E+00	-0.170E+00
-0.259E+00	-0.217E-01	0.705E+00	0.153E+01	0.201E+01	0.183E+01	0.122E+01
0.535E+00	0.332E-01	-0.398E+00	-0.869E+00	-0.140E+01	-0.171E+01	-0.144E+01
-0.598E+00	0.467E+00	0.111E+01	0.101E+01	0.300E+00	-0.422E+00	-0.615E+00

-0.154E+00	0.620E+00	0.129E+01	0.163E+01	0.178E+01	0.188E+01	0.195E+01
0.177E+01	0.124E+01	0.482E+00	-0.174E+00	-0.564E+00	-0.739E+00	-0.102E+01
-0.160E+01	-0.232E+01	-0.271E+01	-0.231E+01	-0.117E+01	0.142E+00	0.826E+00
0.519E+00	-0.437E+00	-0.127E+01	-0.137E+01	-0.828E+00	-0.147E+00	0.269E+00
0.488E+00	0.831E+00	0.143E+01	0.195E+01	0.196E+01	0.137E+01	0.512E+00
-0.152E+00	-0.490E+00	-0.628E+00	-0.744E+00	-0.744E+00	-0.503E+00	0.467E-01
0.737E+00	0.141E+01	0.194E+01	0.221E+01	0.196E+01	0.111E+01	-0.168E+00
-0.127E+01	-0.168E+01	-0.146E+01	-0.121E+01	-0.152E+01	-0.230E+01	-0.284E+01
-0.248E+01	-0.121E+01	0.290E+00	0.128E+01	0.152E+01	0.128E+01	0.883E+00
0.414E+00	-0.197E+00	-0.831E+00	-0.116E+01	-0.921E+00	-0.208E+00	0.516E+00
0.777E+00	0.436E+00	-0.274E+00	-0.102E+01	-0.153E+01	-0.169E+01	-0.154E+01
-0.118E+01	-0.765E+00	-0.450E+00	-0.213E+00	-0.166E-01	0.194E+00	0.319E+00
0.180E+00	-0.253E+00	-0.757E+00	-0.100E+01	-0.752E+00	-0.134E+00	0.517E+00
0.908E+00	0.970E+00	0.843E+00	0.701E+00	0.649E+00	0.662E+00	0.626E+00
0.485E+00	0.284E+00	0.179E+00	0.305E+00	0.637E+00	0.956E+00	0.103E+01
0.912E+00	0.880E+00	0.124E+01	0.192E+01	0.245E+01	0.237E+01	0.167E+01
0.824E+00	0.378E+00	0.465E+00	0.706E+00	0.594E+00	-0.228E-01	-0.819E+00
-0.128E+01	-0.109E+01	-0.284E+00	0.731E+00	0.156E+01	0.195E+01	0.190E+01
0.162E+01	0.127E+01	0.939E+00	0.592E+00	0.167E+00	-0.287E+00	-0.687E+00
-0.966E+00	-0.112E+01	-0.108E+01	-0.716E+00	-0.976E-02	0.760E+00	0.111E+01
0.712E+00	-0.230E+00	-0.111E+01	-0.141E+01	-0.115E+01	-0.781E+00	-0.750E+00
-0.103E+01	-0.126E+01	-0.120E+01	-0.932E+00	-0.757E+00	-0.829E+00	-0.103E+01
-0.113E+01	-0.101E+01	-0.706E+00	-0.361E+00	-0.101E+00	-0.723E-01	-0.293E+00
-0.607E+00	-0.674E+00	-0.222E+00	0.619E+00	0.140E+01	0.166E+01	0.138E+01
0.868E+00	0.533E+00	0.475E+00	0.601E+00	0.801E+00	0.113E+01	0.158E+01
0.200E+01	0.209E+01	0.167E+01	0.860E+00	0.612E-02	-0.609E+00	-0.861E+00
-0.782E+00	-0.429E+00	0.136E+00	0.806E+00	0.149E+01	0.205E+01	0.236E+01
0.232E+01	0.190E+01	0.123E+01	0.603E+00	0.209E+00	0.682E-01	0.156E-03
-0.165E+00	-0.399E+00	-0.554E+00	-0.490E+00	-0.303E+00	-0.125E+00	-0.819E-01
-0.171E+00	-0.415E+00	-0.801E+00	-0.127E+01	-0.155E+01	-0.138E+01	-0.739E+00
0.899E-01	0.688E+00	0.876E+00	0.714E+00	0.410E+00	0.341E-01	-0.410E+00
-0.860E+00	-0.114E+01	-0.113E+01	-0.945E+00	-0.746E+00	-0.579E+00	-0.303E+00
0.214E+00	0.875E+00	0.140E+01	0.158E+01	0.149E+01	0.133E+01	0.123E+01
0.114E+01	0.972E+00	0.690E+00	0.433E+00	0.287E+00	0.297E+00	0.448E+00
0.678E+00	0.908E+00	0.992E+00	0.865E+00	0.629E+00	0.465E+00	0.522E+00
0.768E+00	0.106E+01	0.133E+01	0.163E+01	0.193E+01	0.213E+01	0.206E+01
0.167E+01	0.119E+01	0.803E+00	0.562E+00	0.370E+00	0.183E+00	0.475E-01
0.661E-01	0.193E+00	0.254E+00	0.129E+00	-0.136E+00	-0.440E+00	-0.741E+00
-0.110E+01	0.147E+01	-0.170E+01	-0.165E+01	-0.133E+01	-0.100E+01	-0.898E+00
-0.105E+01	-0.126E+01	-0.141E+01	-0.144E+01	-0.137E+01	-0.119E+01	-0.853E+00
-0.436E+00	-0.122E+00	-0.126E+00	-0.457E+00	-0.916E+00	-0.127E+01	-0.139E+01
-0.134E+01	-0.117E+01	-0.932E+00	-0.613E+00	-0.231E+00	0.136E+00	0.357E+00
0.354E+00	0.158E+00	-0.823E-01	-0.202E+00	-0.127E+00	0.726E-01	0.265E+00
0.383E+00	0.489E+00	0.630E+00	0.745E+00	0.696E+00	0.439E+00	0.179E+00
0.176E+00	0.486E+00	0.890E+00	0.102E+01	0.745E+00	0.250E+00	-0.130E+00
-0.192E+00	0.540E-02	0.304E+00	0.474E+00	0.374E+00	-0.380E-01	-0.624E+00
-0.106E+01	-0.111E+01	-0.726E+00	-0.249E+00	-0.251E-01	-0.167E+00	-0.460E+00
-0.623E+00	-0.632E+00	-0.651E+00	-0.809E+00	-0.107E+01	-0.128E+01	-0.138E+01
-0.141E+01	-0.136E+01	-0.115E+01	-0.729E+00	-0.242E+00	0.657E-01	0.535E-01
-0.117E+00	-0.151E+00	0.395E-01	0.289E+00	0.315E+00	0.627E-01	-0.279E+00
-0.439E+00	-0.306E+00	0.123E-01	0.337E+00	0.498E+00	0.523E+00	0.503E+00
0.595E+00	0.870E+00	0.124E+01	0.153E+01	0.158E+01	0.143E+01	0.122E+01
0.103E+01	0.863E+00	0.665E+00	0.498E+00	0.535E+00	0.869E+00	0.141E+01
0.192E+01	0.228E+01	0.245E+01	0.246E+01	0.218E+01	0.152E+01	0.531E+00
-0.452E+00	-0.106E+01	-0.116E+01	-0.846E+00	-0.404E+00	0.304E-02	0.292E+00
0.404E+00	0.336E+00	0.135E+00	-0.700E-01	-0.228E+00	-0.401E+00	-0.704E+00
-0.109E+01	-0.142E+01	-0.152E+01	-0.144E+01	-0.136E+01	-0.131E+01	-0.117E+01
-0.860E+00	-0.532E+00	-0.545E+00	-0.106E+01	-0.185E+01	-0.247E+01	-0.261E+01
-0.235E+01	-0.190E+01	-0.138E+01	-0.768E+00	-0.127E+00	0.270E+00	0.132E+00
-0.555E+00	-0.142E+01	-0.200E+01	-0.206E+01	-0.171E+01	-0.121E+01	-0.734E+00

-0.354E+00	-0.824E-01	0.919E-01	0.225E+00	0.387E+00	0.606E+00	0.819E+00
0.868E+00	0.681E+00	0.384E+00	0.177E+00	0.242E+00	0.593E+00	0.106E+01
0.149E+01	0.175E+01	0.183E+01	0.178E+01	0.159E+01	0.126E+01	0.851E+00
0.520E+00	0.492E+00	0.861E+00	0.148E+01	0.208E+01	0.243E+01	0.250E+01
0.243E+01	0.232E+01	0.212E+01	0.172E+01	0.113E+01	0.568E+00	0.272E+00
0.316E+00	0.561E+00	0.766E+00	0.830E+00	0.736E+00	0.586E+00	0.422E+00
0.265E+00	0.953E-01	-0.139E+00	-0.438E+00	-0.741E+00	-0.949E+00	-0.939E+00
-0.764E+00	-0.578E+00	-0.549E+00	-0.664E+00	-0.815E+00	-0.884E+00	-0.933E+00
-0.105E+01	-0.126E+01	-0.143E+01	-0.140E+01	-0.120E+01	-0.974E+00	-0.891E+00
-0.955E+00	-0.103E+01	-0.988E+00	-0.767E+00	-0.427E+00	-0.519E-01	0.275E+00
0.497E+00	0.578E+00	0.528E+00	0.385E+00	0.140E+00	-0.164E+00	-0.466E+00
-0.608E+00	-0.492E+00	-0.135E+00	0.290E+00	0.640E+00	0.896E+00	0.109E+01
0.127E+01	0.133E+01	0.121E+01	0.960E+00	0.730E+00	0.613E+00	0.550E+00
0.439E+00	0.304E+00	0.314E+00	0.611E+00	0.114E+01	0.170E+01	0.201E+01
0.188E+01	0.131E+01	0.368E+00	-0.677E+00	-0.148E+01	-0.180E+01	-0.162E+01
-0.117E+01	-0.699E+00	-0.267E+00	0.158E+00	0.558E+00	0.744E+00	0.519E+00
-0.806E-01	-0.773E+00	-0.129E+01	-0.151E+01	-0.155E+01	-0.144E+01	-0.119E+01
-0.786E+00	-0.394E+00	-0.194E+00	-0.260E+00	-0.450E+00	-0.606E+00	-0.709E+00
-0.834E+00	-0.100E+01	-0.109E+01	-0.972E+00	-0.660E+00	-0.242E+00	0.211E+00
0.743E+00	0.131E+01	0.172E+01	0.173E+01	0.127E+01	0.636E+00	0.172E+00
0.726E-01	0.293E+00	0.622E+00	0.911E+00	0.109E+01	0.109E+01	0.891E+00
0.599E+00	0.397E+00	0.344E+00	0.374E+00	0.312E+00	0.181E+00	0.189E+00
0.557E+00	0.119E+01	0.176E+01	0.191E+01	0.164E+01	0.114E+01	0.715E+00
0.500E+00	0.488E+00	0.596E+00	0.664E+00	0.532E+00	0.113E+00	-0.478E+00
-0.946E+00	-0.106E+01	-0.882E+00	-0.685E+00	-0.724E+00	-0.101E+01	-0.135E+01
-0.149E+01	-0.138E+01	-0.101E+01	-0.505E+00	0.983E-02	0.336E+00	0.327E+00
0.278E-01	-0.392E+00	-0.794E+00	-0.120E+01	-0.175E+01	-0.247E+01	-0.311E+01
-0.329E+01	-0.287E+01	-0.196E+01	-0.961E+00	-0.179E+00	0.207E+00	0.210E+00
-0.657E-01	-0.473E+00	-0.864E+00	-0.115E+01	-0.129E+01	-0.127E+01	-0.105E+01
-0.634E+00	-0.130E+00	0.244E+00	0.318E+00	0.123E+00	-0.121E+00	-0.225E+00
-0.136E+00	0.936E-01	0.438E+00	0.921E+00	0.146E+01	0.181E+01	0.177E+01
0.139E+01	0.976E+00	0.833E+00	0.957E+00	0.108E+01	0.100E+01	0.784E+00
0.676E+00	0.814E+00	0.115E+01	0.152E+01	0.186E+01	0.211E+01	0.220E+01
0.201E+01	0.154E+01	0.956E+00	0.461E+00	0.108E+00	-0.203E+00	-0.517E+00
-0.684E+00	-0.457E+00	0.192E+00	0.101E+01	0.161E+01	0.170E+01	0.130E+01
0.565E+00	-0.245E+00	-0.896E+00	-0.124E+01	-0.125E+01	-0.113E+01	-0.106E+01
-0.110E+01	-0.109E+01	-0.896E+00	-0.548E+00	-0.298E+00	-0.319E+00	-0.580E+00
-0.862E+00	-0.101E+01	-0.104E+01	-0.102E+01	-0.968E+00	-0.812E+00	-0.558E+00
-0.374E+00	-0.400E+00	-0.650E+00	-0.955E+00	-0.116E+01	-0.120E+01	-0.111E+01
-0.940E+00	-0.711E+00	-0.436E+00	-0.124E+00	0.259E+00	0.707E+00	0.116E+01
0.145E+01	0.143E+01	0.114E+01	0.802E+00	0.613E+00	0.609E+00	0.620E+00
0.533E+00	0.374E+00	0.269E+00	0.266E+00	0.263E+00	0.149E+00	-0.749E-01
-0.333E+00	-0.577E+00	-0.824E+00	-0.104E+01	-0.108E+01	-0.802E+00	-0.269E+00
0.286E+00	0.586E+00	0.571E+00	0.325E+00	-0.177E-01	-0.403E+00	-0.813E+00
-0.113E+01	-0.120E+01	-0.100E+01	-0.619E+00	-0.287E+00	-0.130E+00	-0.153E+00
-0.327E+00	-0.626E+00	-0.102E+01	-0.143E+01	-0.170E+01	-0.176E+01	-0.162E+01
-0.138E+01	-0.112E+01	-0.815E+00	-0.450E+00	-0.297E-01	0.387E+00	0.708E+00
0.850E+00	0.767E+00	0.473E+00	0.624E-01	-0.346E+00	-0.650E+00	-0.836E+00
-0.892E+00	-0.774E+00	-0.443E+00	0.714E-01	0.595E+00	0.926E+00	0.955E+00
0.746E+00	0.436E+00	0.150E+00	-0.185E-01	-0.542E-02	0.223E+00	0.564E+00
0.798E+00	0.721E+00	0.374E+00	0.199E-01	-0.979E-01	0.552E-01	0.232E+00
0.200E+00	-0.719E-01	-0.413E+00	-0.641E+00	-0.693E+00	-0.652E+00	-0.604E+00
-0.557E+00	-0.514E+00	-0.422E+00	-0.294E+00	-0.143E+00	-0.350E-01	-0.461E-01
-0.203E+00	-0.408E+00	-0.500E+00	-0.409E+00	-0.176E+00	0.815E-01	0.262E+00
0.398E+00	0.502E+00	0.549E+00	0.511E+00	0.362E+00	0.193E+00	0.316E-01
-0.132E+00	-0.339E+00	-0.542E+00	-0.601E+00	-0.436E+00	-0.106E+00	0.203E+00
0.328E+00	0.245E+00	0.263E-01	-0.234E+00	-0.449E+00	-0.519E+00	-0.392E+00
-0.112E+00	0.134E+00	0.210E+00	0.718E-01	-0.113E+00	-0.249E+00	-0.346E+00
-0.499E+00	-0.688E+00	-0.749E+00	-0.517E+00	-0.592E-02	0.577E+00	0.938E+00
0.972E+00	0.682E+00	0.196E+00	-0.345E+00	-0.804E+00	-0.103E+01	-0.101E+01

-0.827E+00	-0.614E+00	-0.419E+00	-0.195E+00	0.124E+00	0.485E+00	0.793E+00
0.994E+00	0.112E+01	0.120E+01	0.120E+01	0.105E+01	0.756E+00	0.461E+00
0.289E+00	0.251E+00	0.273E+00	0.290E+00	0.349E+00	0.491E+00	0.642E+00
0.653E+00	0.413E+00	0.268E-02	-0.357E+00	-0.523E+00	-0.455E+00	-0.276E+00
-0.949E-01	0.366E-01	0.117E+00	0.170E+00	0.201E+00	0.220E+00	0.185E+00
0.611E-01	-0.151E+00	-0.391E+00	-0.602E+00	-0.737E+00	-0.828E+00	-0.879E+00
-0.851E+00	-0.693E+00	-0.411E+00	-0.870E-01	0.187E+00	0.367E+00	0.456E+00
0.426E+00	0.270E+00	0.587E-01	-0.447E-01	0.696E-01	0.327E+00	0.481E+00
0.356E+00	0.490E-01	-0.167E+00	-0.118E+00	0.111E+00	0.279E+00	0.245E+00
0.906E-01	0.233E-01	0.140E+00	0.369E+00	0.611E+00	0.773E+00	0.846E+00
0.823E+00	0.731E+00	0.589E+00	0.461E+00	0.392E+00	0.364E+00	0.352E+00
0.327E+00	0.275E+00	0.146E+00	-0.105E+00	-0.440E+00	-0.717E+00	-0.827E+00
-0.775E+00	-0.688E+00	-0.623E+00	-0.507E+00	-0.193E+00	0.296E+00	0.747E+00
0.917E+00	0.761E+00	0.417E+00	0.715E-01	-0.234E+00	-0.521E+00	-0.787E+00
-0.956E+00	-0.981E+00	-0.911E+00	-0.829E+00	-0.701E+00	-0.452E+00	-0.461E-01
0.406E+00	0.746E+00	0.893E+00	0.859E+00	0.675E+00	0.358E+00	-0.830E-02
0.253E+00	-0.231E+00	0.154E-01	0.304E+00	0.458E+00	0.458E+00	0.402E+00
0.277E+00	0.492E-01	-0.259E+00	-0.461E+00	-0.362E+00	0.354E-01	0.479E+00
0.737E+00	0.800E+00	0.844E+00	0.965E+00	0.106E+01	0.101E+01	0.822E+00
0.627E+00	0.549E+00	0.511E+00	0.363E+00	0.642E-02	-0.474E+00	-0.945E+00
-0.125E+01	-0.127E+01	-0.981E+00	-0.405E+00	0.267E+00	0.761E+00	0.908E+00
0.829E+00	0.689E+00	0.601E+00	0.485E+00	0.221E+00	-0.125E+00	-0.412E+00
-0.515E+00	-0.494E+00	-0.504E+00	-0.585E+00	-0.660E+00	-0.618E+00	-0.454E+00
-0.197E+00	0.142E+00	0.542E+00	0.912E+00	0.109E+01	0.995E+00	0.708E+00
0.393E+00	0.140E+00	-0.233E-01	-0.101E+00	0.757E-02	0.325E+00	0.718E+00
0.946E+00	0.908E+00	0.744E+00	0.665E+00	0.733E+00	0.775E+00	0.626E+00
0.327E+00	0.745E-01	-0.147E-01	0.436E-02	0.161E-01	0.421E-02	0.540E-01
0.218E+00	0.422E+00	0.523E+00	0.476E+00	0.340E+00	0.222E+00	0.190E+00
0.274E+00	0.466E+00	0.680E+00	0.762E+00	0.603E+00	0.285E+00	-0.632E-02
-0.163E+00	-0.246E+00	-0.444E+00	-0.796E+00	-0.111E+01	-0.118E+01	-0.957E+00
-0.647E+00	-0.434E+00	-0.378E+00	-0.388E+00	-0.402E+00	-0.472E+00	-0.631E+00
-0.812E+00	-0.889E+00	-0.811E+00	-0.659E+00	-0.465E+00	-0.235E+00	0.804E-01
0.388E+00	0.540E+00	0.410E+00	0.703E-01	-0.334E+00	-0.680E+00	-0.949E+00
-0.112E+01	-0.110E+01	-0.801E+00	-0.307E+00	0.174E+00	0.449E+00	0.503E+00
0.412E+00	0.298E+00	0.165E+00	0.181E-01	-0.944E-01	-0.792E-01	0.937E-01
0.345E+00	0.600E+00	0.817E+00	0.101E+01	0.116E+01	0.123E+01	0.119E+01
0.105E+01	0.863E+00	0.577E+00	0.164E+00	-0.353E+00	-0.813E+00	-0.109E+01
-0.108E+01	-0.795E+00	-0.293E+00	0.324E+00	0.880E+00	0.113E+01	0.955E+00
0.423E+00	-0.177E+00	-0.589E+00	-0.708E+00	-0.644E+00	-0.488E+00	-0.238E+00
0.171E+00	0.673E+00	0.107E+01	0.119E+01	0.980E+00	0.577E+00	0.151E+00
-0.256E+00	-0.629E+00	-0.976E+00	-0.122E+01	-0.132E+01	-0.130E+01	-0.126E+01
-0.121E+01	-0.114E+01	-0.991E+00	-0.775E+00	-0.582E+00	-0.480E+00	-0.490E+00
-0.553E+00	-0.575E+00	-0.497E+00	-0.336E+00	-0.161E+00	-0.530E-01	-0.260E-01
-0.653E-01	-0.757E-01	-0.274E-01	0.260E-01	-0.255E-01	-0.232E+00	-0.529E+00
-0.810E+00	-0.985E+00	-0.104E+01	-0.100E+01	-0.894E+00	-0.728E+00	-0.511E+00
-0.276E+00	-0.668E-01	0.885E-01	0.162E+00	0.163E+00	0.999E-01	-0.231E-02
-0.592E-01	-0.433E-01	0.562E-01	0.159E+00	0.209E+00	0.211E+00	0.208E+00
0.249E+00	0.342E+00	0.455E+00	0.585E+00	0.699E+00	0.786E+00	0.842E+00
0.846E+00	0.834E+00	0.811E+00	0.743E+00	0.594E+00	0.390E+00	0.198E+00
0.562E-01	-0.353E-01	-0.121E+00	-0.184E+00	-0.180E+00	-0.625E-01	0.137E+00
0.307E+00	0.352E+00	0.280E+00	0.188E+00	0.197E+00	0.310E+00	0.436E+00
0.446E+00	0.327E+00	0.154E+00	0.269E-01	-0.363E-01	-0.911E-01	-0.188E+00
-0.278E+00	-0.309E+00	-0.276E+00	-0.262E+00	-0.342E+00	-0.478E+00	-0.554E+00
-0.509E+00	-0.388E+00	-0.338E+00	-0.402E+00	-0.500E+00	-0.506E+00	-0.373E+00
-0.188E+00	-0.821E-01	-0.730E-01	-0.836E-01	-0.553E-01	-0.900E-02	-0.378E-01
-0.182E+00	-0.379E+00	-0.530E+00	-0.553E+00	-0.474E+00	-0.321E+00	-0.149E+00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

0.564E+00	0.363E+00	0.805E-01	-0.258E+00	-0.541E+00	-0.678E+00	-0.613E+00
-0.378E+00	-0.615E-01	0.232E+00	0.422E+00	0.465E+00	0.381E+00	0.194E+00
-0.996E-02	-0.186E+00	-0.294E+00	-0.368E+00	-0.441E+00	-0.527E+00	-0.569E+00
-0.474E+00	-0.248E+00	0.827E-02	0.147E+00	0.120E+00	0.566E-02	-0.472E-01
0.124E-01	0.122E+00	0.160E+00	0.993E-01	-0.335E-01	-0.157E+00	-0.249E+00
-0.304E+00	-0.316E+00	-0.268E+00	-0.150E+00	-0.311E-01	0.212E-01	-0.195E-01
-0.633E-01	-0.379E-01	0.619E-01	0.154E+00	0.166E+00	0.125E+00	0.109E+00
0.181E+00	0.297E+00	0.365E+00	0.320E+00	0.193E+00	0.529E-01	-0.595E-01
-0.154E+00	-0.244E+00	-0.278E+00	-0.213E+00	-0.419E-01	0.182E+00	0.352E+00
0.413E+00	0.384E+00	0.310E+00	0.250E+00	0.215E+00	0.218E+00	0.253E+00
0.308E+00	0.346E+00	0.345E+00	0.299E+00	0.208E+00	0.953E-01	-0.599E-02
-0.892E-01	-0.159E+00	-0.199E+00	-0.238E+00	-0.247E+00	-0.235E+00	-0.196E+00
-0.126E+00	-0.620E-01	-0.148E-01	-0.174E-01	-0.987E-01	-0.230E+00	-0.376E+00
-0.446E+00	-0.392E+00	-0.225E+00	-0.181E-01	0.147E+00	0.240E+00	0.273E+00
0.249E+00	0.190E+00	0.939E-01	-0.210E-01	-0.107E+00	-0.121E+00	-0.653E-01
0.578E-01	0.182E+00	0.254E+00	0.234E+00	0.127E+00	-0.388E-01	-0.174E+00
-0.213E+00	-0.111E+00	0.789E-01	0.283E+00	0.424E+00	0.468E+00	0.416E+00
0.316E+00	0.183E+00	0.582E-01	-0.466E-01	-0.106E+00	-0.109E+00	-0.767E-01
-0.249E-01	0.197E-01	0.712E-01	0.134E+00	0.231E+00	0.313E+00	0.347E+00
0.311E+00	0.218E+00	0.110E+00	0.236E-01	-0.477E-01	-0.134E+00	-0.226E+00
-0.300E+00	-0.303E+00	-0.229E+00	-0.122E+00	-0.357E-01	-0.656E-02	-0.215E-01
-0.401E-01	-0.226E-01	0.469E-01	0.137E+00	0.225E+00	0.280E+00	0.291E+00
0.287E+00	0.261E+00	0.221E+00	0.149E+00	0.315E-01	-0.120E+00	-0.278E+00
-0.380E+00	-0.372E+00	-0.262E+00	-0.102E+00	0.348E-01	0.128E+00	0.181E+00
0.215E+00	0.207E+00	0.143E+00	0.266E-01	-0.101E+00	-0.185E+00	-0.222E+00
-0.218E+00	-0.182E+00	-0.119E+00	-0.293E-01	0.591E-01	0.115E+00	0.126E+00
0.868E-01	0.176E-01	-0.512E-01	-0.114E+00	-0.143E+00	-0.129E+00	-0.601E-01
0.545E-01	0.164E+00	0.222E+00	0.213E+00	0.152E+00	0.593E-01	-0.443E-01
-0.155E+00	-0.256E+00	-0.333E+00	-0.361E+00	-0.337E+00	-0.289E+00	-0.240E+00
-0.208E+00	-0.190E+00	-0.200E+00	-0.230E+00	-0.293E+00	-0.359E+00	-0.404E+00
-0.368E+00	-0.259E+00	-0.111E+00	0.195E-01	0.736E-01	0.711E-01	0.285E-01
-0.121E-01	-0.373E-01	-0.515E-01	-0.628E-01	-0.858E-01	-0.933E-01	-0.963E-01
-0.865E-01	-0.754E-01	-0.904E-01	-0.142E+00	-0.238E+00	-0.344E+00	-0.414E+00
-0.413E+00	-0.351E+00	-0.267E+00	-0.206E+00	-0.167E+00	-0.141E+00	-0.945E-01
-0.536E-01	-0.239E-01	0.681E-02	0.592E-01	0.168E+00	0.296E+00	0.393E+00
0.401E+00	0.311E+00	0.166E+00	0.209E-01	-0.779E-01	-0.122E+00	-0.114E+00
-0.663E-01	0.547E-02	0.974E-01	0.187E+00	0.235E+00	0.239E+00	0.188E+00
0.106E+00	0.180E-01	-0.449E-01	-0.825E-01	-0.727E-01	-0.350E-01	0.273E-01
0.923E-01	0.134E+00	0.139E+00	0.120E+00	0.100E+00	0.874E-01	0.818E-01
0.569E-01	0.321E-01	0.362E-01	0.825E-01	0.158E+00	0.208E+00	0.201E+00
0.138E+00	-0.607E-01	0.139E-01	-0.155E-01	-0.562E-01	-0.125E+00	-0.194E+00
-0.245E+00	-0.254E+00	-0.244E+00	-0.247E+00	-0.260E+00	-0.261E+00	-0.224E+00
-0.151E+00	-0.670E-01	-0.149E-02	0.406E-01	-0.487E-01	0.346E-01	0.510E-02
-0.187E-01	-0.346E-01	-0.194E-01	0.427E-02	0.130E-01	0.739E-02	0.712E-04
0.105E-03	0.263E-01	0.537E-01	0.646E-01	0.500E-01	0.198E-01	0.132E-01
0.239E-01	0.543E-01	0.852E-01	0.117E+00	0.152E+00	0.187E+00	0.224E+00
0.247E+00	0.266E+00	0.275E+00	0.289E+00	0.281E+00	0.251E+00	0.207E+00
0.191E+00	0.213E+00	0.278E+00	0.346E+00	0.382E+00	0.390E+00	0.375E+00
0.351E+00	0.309E+00	0.249E+00	0.172E+00	0.131E+00	0.127E+00	0.173E+00
0.239E+00	0.288E+00	0.301E+00	0.283E+00	0.243E+00	0.195E+00	0.136E+00
0.805E-01	0.720E-02	-0.691E-01	-0.142E+00	-0.178E+00	-0.154E+00	-0.666E-01
0.457E-01	0.125E+00	0.134E+00	0.752E-01	0.624E-02	-0.477E-01	-0.704E-01
-0.797E-01	-0.112E+00	-0.156E+00	-0.181E+00	-0.180E+00	-0.165E+00	-0.149E+00
-0.153E+00	-0.162E+00	-0.160E+00	-0.145E+00	-0.139E+00	-0.134E+00	-0.127E+00
-0.121E+00	-0.129E+00	-0.180E+00	-0.277E+00	-0.383E+00	-0.447E+00	-0.439E+00
-0.368E+00	-0.281E+00	-0.187E+00	-0.906E-01	0.310E-01	0.150E+00	0.231E+00
0.234E+00	0.179E+00	0.113E+00	0.748E-01	0.550E-01	0.351E-01	-0.377E-02
-0.499E-01	-0.730E-01	-0.795E-01	-0.898E-01	-0.127E+00	-0.165E+00	-0.175E+00
-0.128E+00	-0.717E-01	-0.553E-01	-0.899E-01	-0.129E+00	-0.116E+00	-0.713E-01
-0.471E-01	-0.677E-01	-0.941E-01	-0.642E-01	0.422E-01	0.169E+00	0.253E+00

0.279E+00	0.268E+00	0.252E+00	0.238E+00	0.197E+00	0.132E+00	0.761E-01
0.634E-01	0.103E+00	0.160E+00	0.211E+00	0.245E+00	0.259E+00	0.251E+00
0.189E+00	0.869E-01	-0.286E-01	-0.102E+00	-0.123E+00	-0.111E+00	-0.934E-01
-0.803E-01	-0.469E-01	0.896E-02	0.605E-01	0.719E-01	0.403E-01	-0.106E-02
-0.104E-01	0.596E-02	0.317E-01	0.376E-01	0.302E-01	0.327E-01	0.486E-01
0.611E-01	0.569E-01	0.461E-01	0.339E-01	0.413E-01	0.577E-01	0.675E-01
0.653E-01	0.543E-01	0.251E-01	-0.160E-01	-0.684E-01	-0.119E+00	-0.158E+00
-0.172E+00	-0.168E+00	-0.131E+00	-0.103E+00	-0.111E+00	-0.168E+00	-0.237E+00
-0.252E+00	-0.211E+00	-0.140E+00	-0.941E-01	-0.789E-01	-0.498E-01	0.525E-02
0.591E-01	0.652E-01	0.270E-01	0.290E-02	0.229E-01	0.501E-01	0.313E-01
-0.493E-01	-0.130E+00	-0.154E+00	-0.117E+00	-0.927E-01	-0.951E-01	-0.103E+00
-0.748E-01	-0.147E-01	0.470E-02	-0.460E-01	-0.115E+00	-0.138E+00	-0.110E+00
-0.784E-01	-0.101E+00	-0.148E+00	-0.166E+00	-0.123E+00	-0.383E-01	0.469E-01
0.123E+00	0.205E+00	0.270E+00	0.300E+00	0.267E+00	0.187E+00	0.895E-01
0.150E-02	-0.806E-01	-0.145E+00	-0.191E+00	-0.225E+00	-0.271E+00	-0.343E+00
-0.414E+00	-0.430E+00	-0.378E+00	-0.296E+00	-0.238E+00	-0.212E+00	-0.200E+00
-0.186E+00	-0.187E+00	-0.224E+00	-0.293E+00	-0.327E+00	-0.274E+00	-0.125E+00
0.502E-01	0.198E+00	0.290E+00	0.356E+00	0.385E+00	0.382E+00	0.328E+00
0.263E+00	0.211E+00	0.191E+00	0.165E+00	0.136E+00	0.972E-01	0.613E-01
0.198E-01	-0.500E-01	-0.129E+00	-0.174E+00	-0.170E+00	-0.129E+00	-0.993E-01
-0.970E-01	-0.105E+00	-0.835E-01	-0.461E-01	-0.789E-02	0.120E-01	0.301E-01
0.476E-01	0.453E-01	0.426E-02	-0.624E-01	-0.113E+00	-0.110E+00	-0.466E-01
0.419E-01	0.135E+00	0.218E+00	0.292E+00	0.328E+00	0.295E+00	0.178E+00
0.207E-01	-0.144E+00	-0.257E+00	-0.311E+00	-0.317E+00	-0.303E+00	-0.289E+00
-0.283E+00	-0.267E+00	-0.221E+00	-0.166E+00	-0.119E+00	-0.103E+00	-0.960E-01
-0.752E-01	-0.380E-01	-0.120E-01	-0.848E-02	-0.250E-02	0.617E-01	0.172E+00
0.291E+00	0.349E+00	0.352E+00	0.331E+00	0.332E+00	0.331E+00	0.274E+00
0.150E+00	0.268E-01	-0.242E-01	0.661E-02	0.623E-01	0.100E+00	0.142E+00
0.205E+00	0.269E+00	0.268E+00	0.190E+00	0.850E-01	0.390E-01	0.721E-01
0.138E+00	0.169E+00	0.159E+00	0.158E+00	0.196E+00	0.245E+00	0.244E+00
0.202E+00	0.160E+00	0.157E+00	0.190E+00	0.210E+00	0.199E+00	0.165E+00
0.124E+00	0.934E-01	0.495E-01	-0.980E-02	-0.912E-01	-0.172E+00	-0.231E+00
-0.252E+00	-0.229E+00	-0.177E+00	-0.131E+00	-0.958E-01	-0.700E-01	-0.446E-01
-0.831E-02	0.563E-02	0.330E-02	-0.909E-02	0.800E-02	0.468E-01	0.888E-01
0.922E-01	0.624E-01	0.273E-01	0.260E-01	0.389E-01	0.264E-01	-0.329E-01
-0.113E+00	-0.171E+00	-0.193E+00	-0.204E+00	-0.232E+00	-0.259E+00	-0.268E+00
-0.251E+00	-0.231E+00	-0 229E+00	-0.244E+00	-0.252E+00	-0.241E+00	-0.207E+00
-0.171E+00	-0.139E+00	-0 117E+00	-0.105E+00	-0.976E-01	-0.100E+00	-0.861E 01
-0.338E-01	0.459E-01	0.130E+00	0.172E+00	0.147E+00	0.781E-01	-0.141E-01
-0.951E-01	-0.168E+00	-0.234E+00	-0.290E+00	-0.327E+00	-0.328E+00	-0.298E+00
-0.253E+00	-0.207E+00	-0.159E+00	-0.110E+00	-0.573E-01	-0.310E-01	-0.338E-01
-0.532E-01	-0.607E-01	-0.290E-01	0.312E-01	0.863E-01	0.121E+00	0.148E+00
0.187E+00	0.229E+00	0.215E+00	0.119E+00	-0.394E-02	-0.709E-01	-0.459E-01
-0.459E-02	-0.357E-01	-0.162E+00	-0.299E+00	-0.339E+00	-0.267E+00	-0.147E+00
-0.537E-01	0.772E-02	0.810E-01	0.173E+00	0.238E+00	0.236E+00	0.177E+00
0.133E+00	0.154E+00	0.226E+00	0.304E+00	0.362E+00	0.416E+00	0.455E+00
0.454E+00	0.393E+00	0.300E+00	0.219E+00	0.180E+00	0.165E+00	0.150E+00
0.136E+00	0.123E+00	0.802E-01	-0.116E-01	-0.146E+00	-0.258E+00	-0.310E+00
-0.303E+00	-0.291E+00	-0.299E+00	-0.307E+00	-0.285E+00	-0.230E+00	-0.161E+00
-0.914E-01	-0.131E-01	0.579E-01	0.999E-01	0.999E-01	0.711E-01	0.601E-01
0.953E-01	0.134E+00	0.144E+00	0.114E+00	0.897E-01	0.101E+00	0.106E+00
0.776E-01	0.320E-02	-0.551E-01	-0.730E-01	-0.672E-01	-0.811E-01	-0.116E+00
-0.126E+00	-0.815E-01	-0.230E-01	-0.811E-02	-0.417E-01	-0.682E-01	-0.351E-01
0.385E-01	0.966E-01	0.121E+00	0.151E+00	0.223E+00	0.307E+00	0.330E+00
0.270E+00	0.196E+00	0.190E+00	0.248E+00	0.319E+00	0.357E+00	0.371E+00
0.399E+00	0.434E+00	0.421E+00	0.336E+00	0.215E+00	0.127E+00	0.974E-01
0.917E-01	0.801E-01	0.568E-01	0.517E-01	0.697E-01	0.879E-01	0.929E-01
0.906E-01	0.112E+00	0.164E+00	0.208E+00	0.218E+00	0.188E+00	0.125E+00
0.331E-01	-0.826E-01	-0.205E+00	-0.284E+00	-0.274E+00	-0.204E+00	-0.120E+00
-0.642E-01	-0.313E-01	-0.122E-02	0.197E-01	0.370E-02	-0.478E-01	-0.105E+00

-0.144E+00	-0.169E+00	-0.218E+00	-0.283E+00	-0.318E+00	-0.290E+00	-0.212E+00
-0.150E+00	-0.129E+00	-0.118E+00	-0.733E-01	-0.299E-02	0.361E-01	0.155E-02
-0.729E-01	-0.120E+00	-0.117E+00	-0.825E-01	-0.562E-01	-0.480E-01	-0.369E-01
-0.562E-02	0.625E-02	-0.867E-02	-0.265E-01	-0.388E-02	0.441E-01	0.796E-01
0.588E-01	0.171E-01	0.704E-02	0.457E-01	0.881E-01	0.759E-01	-0.181E-02
-0.955E-01	-0.159E+00	-0.179E+00	-0.172E+00	-0.142E+00	-0.800E-01	0.175E-01
0.113E+00	0.157E+00	0.135E+00	0.741E-01	0.297E-01	0.106E-01	0.150E-01
0.292E-01	0.436E-01	0.665E-01	0.762E-01	0.607E-01	0.155E-01	-0.607E-01
-0.150E+00	-0.217E+00	-0.225E+00	-0.160E+00	-0.695E-01	-0.764E-02	-0.893E-02
-0.416E-01	-0.611E-01	-0.370E-01	-0.397E-02	-0.481E-02	-0.287E-02	0.225E-01
0.570E-01	0.427E-01	-0.435E-01	-0.158E+00	-0.225E+00	-0.222E+00	-0.179E+00
-0.136E+00	-0.907E-01	-0.251E-01	0.477E-01	0.916E-01	0.922E-01	0.891E-01
0.125E+00	0.207E+00	0.277E+00	0.295E+00	0.273E+00	0.254E+00	0.251E+00
0.259E+00	0.243E+00	0.207E+00	0.172E+00	0.141E+00	0.948E-01	0.215E-01
-0.514E-01	-0.850E-01	-0.784E-01	-0.591E-01	-0.560E-01	-0.634E-01	-0.505E-01
-0.212E-01	-0.154E-01	-0.372E-01	-0.611E-01	-0.548E-01	-0.249E-01	-0.137E-01
-0.326E-01	-0.703E-01	-0.857E-01	-0.788E-01	-0.667E-01	-0.633E-01	-0.493E-01
-0.200E-01	0.139E-01	0.251E-01	-0.300E-02	-0.434E-01	-0.685E-01	-0.878E-01
-0.123E+00	-0.186E+00	-0.250E+00	-0.295E+00	-0.320E+00	-0.366E+00	-0.414E+00
-0.413E+00	-0.355E+00	-0.276E+00	-0.227E+00	-0.214E+00	-0.188E+00	-0.122E+00
-0.227E-01	0.534E-01	0.995E-01	0.136E+00	0.180E+00	0.201E+00	0.165E+00
0.813E-01	0.381E-02	-0.286E-01	-0.212E-01	-0.714E-02	0.443E-03	0.108E-01
0.258E-01	0.314E-01	0.115E-01	0.406E-02	0.344E-01	0.100E+00	0.155E+00
0.174E+00	0.174E+00	0.206E+00	0.264E+00	0.307E+00	0.289E+00	0.223E+00
0.176E+00	0.186E+00	0.226E+00	0.247E+00	0.223E+00	0.172E+00	0.115E+00
0.575E-01	0.281E-02	-0.330E-01	-0.377E-01	-0.293E-01	-0.391E-01	-0.802E-01
-0.108E+00	-0.882E-01	-0.367E-01	-0.108E-01	-0.365E-01	-0.920E-01	-0.128E+00
-0.135E+00	-0.145E+00	-0.172E+00	-0.203E+00	-0.200E+00	-0.169E+00	-0.155E+00
-0.191E+00	-0.234E+00	-0.228E+00	-0.165E+00	-0.107E+00	-0.114E+00	-0.176E+00
-0.237E+00	-0.261E+00	-0.273E+00	-0.302E+00	-0.318E+00	-0.282E+00	-0.195E+00
-0.119E+00	-0.106E+00	-0.136E+00	-0.150E+00	-0.114E+00	-0.571E-01	-0.284E-01
-0.188E-01	0.115E-01	0.685E-01	0.117E+00	0.121E+00	0.874E-01	0.679E-01
0.773E-01	0.977E-01	0.110E+00	0.118E+00	0.147E+00	0.190E+00	0.212E+00
0.185E+00	0.134E+00	0.103E+00	0.108E+00	0.111E+00	0.796E-01	0.330E-01
0.219E-02	0.529E-02	0.152E-01	0.286E-01	0.491E-01	0.954E-01	0.156E+00
0.191E+00	0.182E+00	0.160E+00	0.151E+00	0.151E+00	0.131E+00	0.824E-01
0.354E-01	0.241E-01	0.399E-01	0.431E-01	0.205E-01	-0.687E-02	-0.837E-02
0.511E-02	0.251E-03	-0.420E-01	-0.939E-01	-0.120E+00	-0.125E+00	-0.133E+00
-0.174E+00	-0.222E+00	-0.245E+00	-0.229E+00	-0.195E+00	-0.167E+00	-0.142E+00
-0.104E+00	-0.536E-01	-0.219E-01	-0.174E-01	-0.335E-01	-0.476E-01	-0.625E-01
-0.920E-01	-0.133E+00	-0.160E+00	-0.146E+00	-0.107E+00	-0.745E-01	-0.715E-01
-0.887E-01	-0.105E+00	-0.110E+00	-0.110E+00	-0.110E+00	-0.971E-01	-0.628E-01
-0.784E-02	0.451E-01	0.759E-01	0.860E-01	0.899E-01	0.919E-01	0.886E-01
0.665E-01	0.446E-01	0.273E-01	0.226E-01	0.180E-01	0.184E-01	0.286E-01
0.522E-01	0.688E-01	0.765E-01	0.860E-01	0.121E+00	0.176E+00	0.226E+00
0.246E+00	0.241E+00	0.230E+00	0.210E+00	0.169E+00	0.110E+00	0.601E-01
0.510E-01	0.824E-01	0.127E+00	0.141E+00	0.130E+00	0.116E+00	0.113E+00
0.108E+00	0.799E-01	0.429E-01	0.252E-01	0.396E-01	0.654E-01	0.811E-01
0.925E-01	0.120E+00	0.165E+00	0.200E+00	0.195E+00	0.163E+00	0.135E+00
0.125E+00	0.109E+00	0.615E-01	-0.760E-02	-0.645E-01	-0.881E-01	-0.944E-01
-0.109E+00	-0.137E+00	-0.155E+00	-0.145E+00	-0.109E+00	-0.665E-01	-0.346E-01
-0.180E-01	-0.111E-01	-0.185E-01	-0.380E-01	-0.588E-01	-0.685E-01	-0.653E-01
-0.662E-01	-0.735E-01	-0.772E-01	-0.580E-01	-0.219E-01	0.895E-02	0.109E-01
-0.568E-02	-0.256E-01	-0.420E-01	-0.735E-01	-0.125E+00	-0.175E+00	-0.186E+00
-0.165E+00	-0.143E+00	-0.150E+00	-0.170E+00	-0.172E+00	-0.143E+00	-0.105E+00
-0.832E-01	-0.778E-01	-0.636E-01	-0.272E-01	0.198E-01	0.556E-01	0.803E-01
0.105E+00	0.129E+00	0.136E+00	0.105E+00	0.462E-01	-0.488E-02	-0.270E-01
-0.327E-01	-0.496E-01	-0.766E-01	-0.895E-01	-0.719E-01	-0.398E-01	-0.124E-01
0.384E-02	0.245E-01	0.583E-01	0.928E-01	0.897E-01	0.466E-01	-0.243E-02
-0.190E-01	0.533E-02	0.461E-01	0.881E-01	0.123E+00	0.158E+00	0.176E+00

0.168E+00	0.135E+00	0.105E+00	0.816E-01	0.503E-01	-0.545E-02	-0.711E-01
-0.113E+00	-0.111E+00	-0.863E-01	-0.649E-01	-0.594E-01	-0.554E-01	-0.509E-01
-0.559E-01	-0.774E-01	-0.103E+00	-0.116E+00	-0.115E+00	-0.119E+00	-0.140E+00
-0.166E+00	-0.175E+00	-0.148E+00	-0.110E+00	-0.815E-01	-0.610E-01	-0.316E-01
0.615E-02	0.210E-01	-0.106E-01	-0.744E-01	-0.119E+00	-0.126E+00	-0.119E+00
-0.147E+00	-0.204E+00	-0.241E+00	-0.231E+00	-0.197E+00	-0.175E+00	-0.165E+00
-0.128E+00	-0.499E-01	0.278E-01	0.460E-01	0.325E-02	-0.417E-01	-0.396E-01
-0.107E-01	-0.113E-01	-0.584E-01	-0.106E+00	-0.100E+00	-0.447E-01	0.167E-01
0.510E-01	0.744E-01	0.937E-01	0.107E+00	0.838E-01	0.360E-01	-0.104E-01
-0.135E-01	0.953E-02	0.262E-01	0.186E-01	0.469E-02	0.142E-01	0.568E-01
0.112E+00	0.151E+00	0.178E+00	0.199E+00	0.212E+00	0.205E+00	0.177E+00
0.136E+00	0.106E+00	0.852E-01	0.633E-01	0.358E-01	0.206E-01	0.163E-01
0.116E-01	0.408E-02	-0.623E-02	-0.135E-01	-0.189E-01	-0.390E-01	-0.565E-01
-0.589E-01	-0.294E-01	0.899E-02	0.221E-01	0.631E-02	-0.104E-01	0.226E-03
0.185E-01	0.113E-01	-0.285E-01	-0.608E-01	-0.362E-01	0.356E-01	0.894E-01
0.842E-01	0.234E-01	-0.245E-01	-0.329E-01	-0.111E-01	-0.113E-01	-0.363E-01
-0.377E-01	-0.421E-02	0.372E-01	0.406E-01	0.177E-01	-0.504E-03	0.167E-01
0.458E-01	0.500E-01	0.352E-01	0.232E-01	0.381E-01	0.585E-01	0.697E-01
0.645E-01	0.769E-01	0.118E+00	0.169E+00	0.195E+00	0.183E+00	0.166E+00
0.166E+00	0.171E+00	0.151E+00	0.106E+00	0.603E-01	0.459E-01	0.541E-01
0.526E-01	0.299E-01	-0.509E-02	-0.333E-01	-0.371E-01	-0.282E-01	-0.122E-01
0.189E-01	0.648E-01	0.107E+00	0.116E+00	0.967E-01	0.628E-01	0.462E-01
0.254E-01	0.396E-02	-0.399E-01	-0.816E-01	-0.113E+00	-0.133E+00	-0.136E+00
-0.964E-01	-0.288E-01	0.343E-01	0.680E-01	0.601E-01	0.454E-01	0.590E-01
0.105E+00	0.147E+00	0.165E+00	0.149E+00	0.134E+00	0.119E+00	0.102E+00
0.717E-01	0.441E-01	0.409E-01	0.637E-01	0.894E-01	0.893E-01	0.712E-01
0.500E-01	0.454E-01	0.472E-01	0.434E-01	0.400E-01	0.497E-01	0.805E-01
0.105E+00	0.102E+00	0.716E-01	0.469E-01	0.443E-01	0.606E-01	0.772E-01
0.936E-01	0.112E+00	0.137E+00	0.163E+00	0.166E+00	0.147E+00	0.111E+00
0.644E-01	0.133E-01	-0.336E-01	-0.730E-01	-0.819E-01	-0.774E-01	-0.728E-01
-0.816E-01	-0.108E+00	-0.142E+00	-0.161E+00	-0.158E+00	-0.132E+00	-0.959E-01
-0.734E-01	-0.767E-01	-0.106E+00	-0.132E+00	-0.130E+00	-0.865E-01	-0.226E-01
0.310E-01	0.599E-01	0.673E-01	0.718E-01	0.690E-01	0.594E-01	0.372E-01
0.174E-01	0.523E-02	-0.775E-04	-0.980E-02	-0.247E-01	-0.292E-01	-0.111E-01
0.251E-01	0.558E-01	0.725E-01	0.758E-01	0.778E-01	0.851E-01	0.897E-01
0.810E-01	0.791E-01	0.934E-01	0.121E+00	0.129E+00	0.850E-01	-0.536E-04
-0.949E-01	-0.154E+00	-0.157E+00	-0.117E+00	-0.509E-01	0.868E-02	0.512E-01
0.758E-01	0.867E-01	0.881E-01	0.788E-01	0.566E-01	0.224E-01	-0.176E-01
-0.443E-01	-0.521E-01	-0.490E-01	-0.406E-01	-0.334E-01	-0.179E-01	-0.422E-03
0.147E-01	0.114E-01	0.662E-02	0.568E-02	0.146E-01	0.189E-01	0.913E-02
-0.146E-01	-0.414E-01	-0.610E-01	-0.729E-01	-0.795E-01	-0.826E-01	-0.857E-01
-0.904E-01	-0.104E+00	-0.124E+00	-0.135E+00	-0.106E+00	-0.352E-01	0.363E-01
0.131E+00	0.169E+00	0.183E+00	0.186E+00	0.182E+00	0.167E+00	0.145E+00
0.125E+00	0.110E+00	0.943E-01	0.705E-01	0.479E-01	0.380E-01	0.444E-01
0.499E-01	0.323E-01	0.227E-02	-0.252E-01	-0.292E-01	-0.170E-01	-0.863E-02
-0.110E-01	-0.183E-01	-0.225E-01	-0.231E-01	-0.256E-01	-0.215E-01	-0.376E-03
0.374E-01	0.668E-01	0.759E-01	0.666E-01	0.705E-01	0.950E-01	0.124E+00
0.135E+00	0.120E+00	0.992E-01	0.879E-01	0.758E-01	0.489E-01	0.665E-02
-0.285E-01	-0.381E-01	-0.217E-01	0.847E-02	0.437E-01	0.936E-01	0.151E+00
0.200E+00	0.218E+00	0.210E+00	0.191E+00	0.167E+00	0.128E+00	0.703E-01
0.852E-02	-0.214E-01	-0.459E-02	0.450E-01	0.905E-01	0.112E+00	0.110E+00
0.897E-01	0.494E-01	-0.230E-02	-0.518E-01	-0.762E-01	-0.732E-01	-0.653E-01
-0.800E-01	-0.106E+00	-0.115E+00	-0.867E-01	-0.389E-01	0.477E-03	0.765E-02
0.142E-02	-0.691E-02	-0.180E-01	-0.436E-01	-0.902E-01	-0.134E+00	-0.154E+00
-0.158E+00	-0.152E+00	-0.159E+00	-0.168E+00	-0.171E+00	-0.172E+00	-0.169E+00
-0.162E+00	-0.137E+00	-0.930E-01	-0.506E-01	-0.256E-01	-0.227E-01	-0.203E-01
-0.986E-02	-0.579E-02	-0.262E-01	-0.848E-01	-0.159E+00	-0.222E+00	-0.252E+00
-0.235E+00	-0.175E+00	-0.796E-01	0.207E-01	0.104E+00	0.155E+00	0.188E+00
0.218E+00	0.245E+00	0.246E+00	0.202E+00	0.124E+00	0.456E-01	-0.223E-02
-0.193E-01	-0.153E-01	0.384E-02	0.354E-01	0.714E-01	0.101E+00	0.107E+00

0.910E-01	0.732E-01	0.609E-01	0.497E-01	0.269E-01	-0.779E-02	-0.377E-01
-0.531E-01	-0.628E-01	-0.695E-01	-0.749E-01	-0.681E-01	-0.484E-01	-0.312E-01
-0.294E-01	-0.486E-01	-0.597E-01	-0.567E-01	-0.434E-01	-0.351E-01	-0.475E-01
-0.720E-01	-0.922E-01	-0.112E+00	-0.131E+00	-0.150E+00	-0.153E+00	-0.141E+00
-0.120E+00	-0.105E+00	-0.104E+00	-0.107E+00	-0.113E+00	-0.114E+00	-0.114E+00
-0.111E+00	-0.102E+00	-0.908E-01	-0.861E-01	-0.103E+00	-0.141E+00	-0.180E+00
-0.204E+00	-0.204E+00	-0.182E+00	-0.151E+00	-0.116E+00	-0.843E-01	-0.676E-01
-0.661E-01	-0.842E-01	-0.973E-01	-0.102E+00	-0.103E+00	-0.121E+00	-0.147E+00
-0.162E+00	-0.144E+00	-0.962E-01	-0.451E-01	-0.172E-01	-0.165E-01	-0.295E-01
-0.420E-01	-0.551E-01	-0.707E-01	-0.936E-01	-0.114E+00	-0.136E+00	-0.160E+00
-0.187E+00	-0.206E+00	-0.199E+00	-0.176E+00	-0.152E+00	-0.140E+00	-0.134E+00
-0.118E+00	-0.806E-01	-0.444E-01	-0.214E-01	-0.266E-01	-0.451E-01	-0.743E-01
-0.105E+00	-0.131E+00	-0.139E+00	-0.122E+00	-0.855E-01	-0.474E-01	-0.166E-01
0.149E-01	0.608E-01	0.114E+00	0.159E+00	0.179E+00	0.183E+00	0.182E+00
0.182E+00	0.175E+00	0.153E+00	0.124E+00	0.104E+00	0.980E-01	0.101E+00
0.101E+00	0.104E+00	0.103E+00	0.101E+00	0.880E-01	0.659E-01	0.532E-01
0.501E-01	0.488E-01	0.306E-01	-0.682E-02	0.373E-01	-0.413E-01	-0.130E-01
0.227E-01	0.477E-01	0.507E-01	0.449E-01	0.335E-01	0.182E-01	0.243E-02
-0.856E-02	-0.124E-01	-0.154E-01	-0.162E-01	-0.165E-01	-0.858E-02	0.226E-02
0.570E-02	0.106E-01	-0.443E-01	-0.826E-01	-0.112E+00	-0.131E+00	-0.147E+00
-0.166E+00	-0.178E+00	-0.177E+00	-0.160E+00	-0.129E+00	-0.902E-01	-0.518E-01
-0.758E-02	0.344E-01	0.639E-01	0.804E-01	0.939E-01	0.106E+00	0.123E+00
0.133E+00	0.129E+00	0.118E+00	0.110E+00	0.106E+00	0.104E+00	0.926E-01
0.810E-01	0.809E-01	0.988E-01	0.134E+00	0.175E+00	0.211E+00	0.234E+00
0.240E+00	0.224E+00	0.186E+00	0.142E+00	0.103E+00	0.727E-01	0.514E-01
0.271E-01	0.561E-02	-0.471E-02	0.162E-02	0.213E-01	0.475E-01	0.748E-01
0.101E+00	0.119E+00	0.118E+00	0.971E-01	0.687E-01	0.476E-01	0.354E-01
0.254E-01	0.438E-02	-0.222E-01	-0.398E-01	-0.331E-01	-0.103E-01	0.204E-01
0.471E-01	0.680E-01	0.787E-01	0.737E-01	0.533E-01	0.304E-01	0.248E-01
0.376E-01	0.530E-01	0.525E-01	0.343E-01	0.151E-01	0.907E-02	0.149E-01
0.256E-01	0.364E-01	0.506E-01	0.715E-01	0.860E-01	0.840E-01	0.717E-01
0.730E-01	0.992E-01	0.144E+00	0.184E+00	0.204E+00	0.204E+00	0.197E+00
0.186E+00	0.174E+00	0.153E+00	0.127E+00	0.101E+00	0.878E-01	0.848E-01
0.861E-01	0.904E-01	0.880E-01	0.790E-01	0.614E-01	0.410E-01	0.297E-01
0.268E-01	0.314E-01	0.377E-01	0.473E-01	0.618E-01	0.804E-01	0.908E-01
0.869E-01	0.635E-01	0.342E-01	0.513E-02	-0.197E-01	-0.467E-01	-0.753E-01
-0.101E+00	-0.116E+00	-0.120E+00	-0.111E+00	-0.915E-01	-0.621E-01	-0.316E-01
-0.901E-02	-0.283E-02	-0.110E-01	-0.197E-01	-0.242E-01	-0.253E-01	-0.333E-01
-0.503E-01	-0.688E-01	-0.785E-01	-0.727E-01	-0.553E-01	-0.326E-01	-0.123E-01
0.542E-02	0.159E-01	0.204E-01	0.248E-01	0.310E-01	0.375E-01	0.363E-01
0.269E-01	0.105E-01	0.148E-02	0.140E-02	0.611E-02	0.177E-01	0.366E-01
0.638E-01	0.989E-01	0.130E+00	0.147E+00	0.153E+00	0.152E+00	0.145E+00
0.136E+00	0.127E+00	0.118E+00	0.109E+00	0.933E-01	0.638E-01	0.262E-01
-0.151E-01	-0.427E-01	-0.588E-01	-0.689E-01	-0.836E-01	-0.102E+00	-0.118E+00
-0.126E+00	-0.128E+00	-0.118E+00	-0.104E+00	-0.830E-01	-0.624E-01	-0.500E-01
-0.452E-01	-0.475E-01	-0.527E-01	-0.569E-01	-0.620E-01	-0.613E-01	-0.589E-01
-0.541E-01	-0.501E-01	-0.495E-01	-0.561E-01	-0.652E-01	-0.798E-01	-0.910E-01
-0.100E+00	-0.104E+00	-0.104E+00	-0.943E-01	-0.819E-01	-0.702E-01	-0.637E-01
-0.552E-01	-0.402E-01	-0.224E-01	-0.176E-02	0.123E-01	0.260E-01	0.437E-01
0.679E-01	0.887E-01	0.938E-01	0.949E-01	0.817E-01	0.567E-01	0.298E-01
-0.521E-02	-0.367E-01	-0.645E-01	-0.347E-01	-0.993E-01	-0.111E+00	-0.119E+00
-0.121E+00	-0.115E+00	-0.109E+00	-0.104E+00	-0.101E+00	-0.954E-01	-0.872E-01
-0.818E-01	-0.838E-01	-0.922E-01	-0.102E+00	-0.102E+00	-0.935E-01	-0.824E-01
-0.738E-01	-0.730E-01	-0.824E-01	-0.101E+00	-0.117E+00	-0.128E+00	-0.121E+00
-0.106E+00	-0.882E-01	-0.772E-01	-0.740E-01	-0.750E-01	-0.754E-01	-0.779E-01
-0.798E-01	-0.808E-01	-0.744E-01	-0.620E-01	-0.467E-01	-0.338E-01	-0.223E-01
-0.899E-02	0.112E-01	0.294E-01	0.448E-01	0.554E-01	0.654E-01	0.793E-01
0.932E-01	0.110E+00	0.123E+00	0.130E+00	0.134E+00	0.126E+00	0.107E+00
0.839E-01	0.548E-01	0.318E-01	0.864E-02	-0.133E-01	-0.409E-01	-0.615E-01
-0.752E-01	-0.797E-01	-0.764E-01	-0.669E-01	-0.527E-01	-0.422E-01	-0.380E-01

-0.432E-01	-0.545E-01	-0.627E-01	-0.666E-01	-0.705E-01	-0.765E-01	-0.865E-01
-0.927E-01	-0.100E+00	-0.108E+00	-0.115E+00	-0.119E+00	-0.121E+00	-0.120E+00
-0.123E+00	-0.133E+00	-0.143E+00	-0.147E+00	-0.145E+00	-0.140E+00	-0.134E+00
-0.129E+00	-0.123E+00	-0.123E+00	-0.130E+00	-0.142E+00	-0.148E+00	-0.141E+00
-0.119E+00	-0.950E-01	-0.730E-01	-0.472E-01	-0.189E-01	0.107E-01	0.310E-01
0.398E-01	0.346E-01	0.257E-01	0.135E-01	-0.457E-02	-0.268E-01	-0.414E-01
-0.432E-01	-0.333E-01	-0.202E-01	-0.602E-02	0.686E-02	0.251E-01	0.462E-01
0.605E-01	0.694E-01	0.713E-01	0.699E-01	0.604E-01	0.424E-01	0.207E-01
0.143E-02	-0.947E-02	-0.131E-01	-0.149E-01	-0.153E-01	-0.141E-01	-0.727E-02
0.210E-02	0.647E-02	0.722E-02	0.254E-02	0.150E-02	0.263E-02	0.160E-02
-0.430E-02	-0.150E-01	-0.257E-01	-0.339E-01	-0.398E-01	-0.467E-01	-0.511E-01
-0.528E-01	-0.528E-01	-0.542E-01	-0.608E-01	-0.714E-01	-0.820E-01	-0.892E-01
-0.942E-01	-0.965E-01	-0.918E-01	-0.774E-01	-0.549E-01	-0.322E-01	-0.127E-01
-0.340E-03	0.948E-02	0.199E-01	0.286E-01	0.331E-01	0.312E-01	0.287E-01
0.241E-01	0.207E-01	0.210E-01	0.263E-01	0.399E-01	0.577E-01	0.772E-01
0.889E-01	0.933E-01	0.922E-01	0.899E-01	0.834E-01	0.733E-01	0.596E-01
0.479E-01	0.401E-01	0.369E-01	0.344E-01	0.340E-01	0.350E-01	0.411E-01
0.495E-01	0.528E-01	0.549E-01	0.557E-01	0.589E-01	0.585E-01	0.516E-01
0.385E-01	0.290E-01	0.258E-01	0.249E-01	0.222E-01	0.154E-01	0.929E-02
0.694E-02	0.437E-02	0.158E-02	-0.402E-02	-0.968E-02	-0.146E-01	-0.220E-01
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0.782E-02	0.190E-01	0.289E-01	0.337E-01	0.323E-01	0.316E-01	0.344E-01
0.362E-01	0.354E-01	0.333E-01	0.363E-01	0.478E-01	0.622E-01	0.730E-01
0.793E-01	0.813E-01	0.812E-01	0.746E-01	0.595E-01	0.391E-01	0.204E-01
0.895E-02	0.459E-02	0.460E-02	0.695E-02	0.148E-01	0.269E-01	0.407E-01
0.499E-01	0.534E-01	0.511E-01	0.491E-01	0.468E-01	0.418E-01	0.351E-01
0.293E-01	0.240E-01	0.218E-01	0.176E-01	0.154E-01	0.130E-01	0.163E-01
0.162E-01	0.151E-01	0.486E-02	-0.927E-02	-0.212E-01	-0.312E-01	-0.365E-01
-0.408E-01	-0.441E-01	-0.431E-01	-0.401E-01	-0.401E-01	-0.386E-01	-0.359E-01
-0.284E-01	-0.164E-01	-0.597E-02	0.424E-02	0.111E-01	0.208E-01	0.300E-01
0.358E-01	0.349E-01	0.340E-01	0.335E-01	0.345E-01	0.361E-01	0.355E-01
0.357E-01	0.373E-01	0.394E-01	0.395E-01	0.371E-01	0.340E-01	0.354E-01
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0.110E-03	-0.518E-02	-0.923E-02	-0.132E-01	-0.163E-01	-0.130E-01	-0.685E-02
0.626E-03	0.581E-02	0.934E-02	0.137E-01	0.135E-01	0.652E-02	-0.196E-02
-0.104E-01	-0.120E-01	-0.108E-01	-0.111E-01	-0.152E-01	-0.186E-01	-0.211E-01
-0.215E-01	-0.262E-01	-0.330E-01	-0.413E-01	-0.446E-01	-0.456E-01	-0.479E-01
-0.512E-01	-0.515E-01	-0.437E-01	-0.336E-01	-0.224E-01	-0.151E-01	-0.785E-02
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0.294E-01	0.314E-01	0.350E-01	0.389E-01	0.446E-01	0.477E-01	0.503E-01
0.523E-01	0.605E-01	0.653E-01	0.634E-01	0.566E-01	0.467E-01	0.388E-01
0.359E-01	0.299E-01	0.236E-01	0.184E-01	0.175E-01	0.193E-01	0.223E-01
0.283E-01	0.316E-01	0.424E-01	0.464E-01	0.442E-01	0.356E-01	0.241E-01
0.158E-01	0.105E-01	0.810E-02	0.651E-02	0.775E-02	0.108E-01	0.158E-01
0.165E-01	0.154E-01	0.130E-01	0.133E-01	0.115E-01	0.706E-02	-0.922E-03
-0.592E-02	-0.972E-02	-0.113E-01	-0.114E-01	-0.120E-01	-0.122E-01	-0.765E-02
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0.434E-01	0.422E-01	0.365E-01	0.325E-01	0.277E-01	0.272E-01	0.268E-01
0.265E-01	0.252E-01	0.235E-01	0.244E-01	0.260E-01	0.251E-01	0.239E-01
0.212E-01	0.204E-01	0.215E-01	0.227E-01	0.233E-01	0.246E-01	0.280E-01
0.310E-01	0.324E-01	0.294E-01	0.282E-01	0.258E-01	0.272E-01	0.295E-01
0.309E-01	0.314E-01	0.313E-01	0.301E-01	0.228E-01	0.165E-01	0.872E-02
0.582E-02	0.364E-02	0.347E-02	0.191E-02	-0.641E-04	-0.158E-03	0.248E-02
0.714E-02	0.116E-01	0.171E-01	0.225E-01	0.306E-01	0.341E-01	0.368E-01
0.383E-01	0.417E-01	0.466E-01	0.514E-01	0.520E-01	0.516E-01	0.501E-01
0.472E-01	0.420E-01	0.355E-01	0.315E-01	0.305E-01	0.352E-01	0.419E-01
0.455E-01	0.491E-01	0.519E-01	0.540E-01	0.535E-01	0.483E-01	0.419E-01
0.353E-01	0.221E-01	0.230E-01	0.160E-01	0.104E-01	0.102E-01	0.121E-01

0.148E-01	0.157E 01	0.154E-01	0.150E-01	0.165E-01	0.160E-01	0.141E-01
0.115E-01	0.963E-02	0.761E-02	0.420E-02	-0.786E-03	-0.629E-02	-0.796E-02
-0.829E-02	-0.933E-02	-0.106E-01	-0.120E-01	-0.130E-01	-0.136E-01	-0.153E-01
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-0 884E-02	0.719E-02	-0.561E-02	-0.708E-02	-0.762E-02	-0.691E-02	-0.554E-02
-0.738E-02	-0.944E-02	-0.124E-01	-0.112E-01	-0.765E-02	-0.452E-02	-0.287E-02
-0.157E-02	0.116E-03	0.243E-02	0.179E-02	-0.187E-02	-0.552E-02	-0.583E-02
-0.488E-02	-0.430E-02	-0.621E-02	-0.865E-02	-0.946E-02	-0.988E-02	-0.122E-01
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-0.234E-01	-0.254E-01	-0.315E-01	-0.359E-01	-0.371E-01	-0.379E-01	-0.389E-01
-0.393E-01	0.384E-01	-0.331E-01	-0.258E-01	-0.200E-01	-0.167E-01	-0.142E 01
-0.110E-01	-0.859E-02	-0.862E-02	-0.120E-01	-0.170E-01	-0.181E-01	-0.177E-01
-0.199E-01	-0 192E-01	-0.213E-01	-0.194E-01	-0.154E-01	0.138E-01	-0.154E-01
-0.163E 01	-0 166E 01	-0.140E-01	-0.196E-01	-0.244E-01	-0.317E-01	-0.359E-01
-0.393E-01	0 441E-01	0.515E-01	-0.566E-01	-0.578E-01	-0.556E-01	-0.522E-01
-0.508E-01	0 482E 01	-0.455E-01	-0.442E-01	-0 445E-01	-0.502E-01	-0.555E-01
0 580E-01	0.577E 01	-0.575E-01	-0.573E-01	-0.588E-01	-0.536E-01	-0.487E 01
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-0.258E-01	-0 231E-01	-0.242E-01	-0.248E-01	-0.244E-01	-0.193E-01	-0.206E-01
-0 205E-01	-0 214E-01	-0.219E-01	-0.174E-01	-0.178E-01	-0.171E-01	-0.195E-01
-0.174E-01	-0 148E-01	-0.133E-01	-0.159E-01	-0.174E-01	-0.193E-01	-0 165E 01
-0.168E-01	-0.203E 01	0.250E-01	-0.255E-01	-0.248E-01	-0.240E-01	-0 239E 01
0.275E-01	-0 267E-01	0.260E-01	-0.299E-01	-0.335E-01	-0.403E-01	-0 412E 01
-0.411E-01	-0.389E-01	-0.393E-01	-0.414E-01	-0.383E-01	-0.344E-01	-0.325E 01
-0 331E-01	-0 351E-01	-0 341E-01	-0.307E-01	-0.315E-01	-0.316E-01	-0.339E 01
-0.316E-01	-0.271E-01	-0.213E-01	-0.215E-01	-0.190E-01	-0.169E-01	-0.135E-01
-0 118E-01	-0.133E-01	-0.148E-01	-0.139E-01	-0.126E-01	-0.126E-01	-0.168E-01
0 198E-01	-0.189E 01	-0 160E-01	-0.143E-01	-0 165E-01	-0.184E-01	-0.176E 01
0.151E-01	-0.139E 01	-0 156E-01	-0.190E-01	-0 171E-01	-0.163E-01	-0.157E-01
-0 190E-01	-0 223E-01	-0.229E-01	-0.227E-01	-0.207E-01	-0.216E-01	-0.218E 01
0 199E-01	0 159E-01	0 139E-01	-0.149E-01	-0 184E-01	-0.178E-01	-0.154E-01

ANNEXURE-12

प्रोफेसर र. ना. अयंगार
निदेशक
Prof. R.N. IYENGAR
Director

केन्द्रीय भवन अनुसंधान संस्थान
रुड़की - २४७ ६६७ (भारत)
CENTRAL BUILDING RESEARCH INSTITUTE
ROORKEE - 247 667 (INDIA)

Feb. 14, 1998
PA/TD

Sri Sailesh
Deputy Secretary,
Ministery of Power,
Shram Shakti Bhawan,
Rafi Marg, New Delhi.

Fax: 011-3717519

Sub: **Group of Experts on Safety of Tehri Dam**

Dear Sri Sailesh,

This has reference to your letter dated 9th Feb. 1998 enclosing a copy of the draft report on the above subject. The enclosed modifications have to be incorporated into the body of the report to reflect my views correctly.

With regards

Yours sincerely

(R.N. Iyengar)

cc:

1. Prof. N.C. Nigam
2. Prof. V.K. Gaur
3. Prof. K.N. Khattri
4. Prof. Ramesh Chander

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MODIFICTAIONS TO BE INCORPORATED

i) The minutes and correspondence of the meeting held in the office of Prof. N.C. Nigam at Roorkee, on 25.2.1997 should form part of the report.

P.3 MEETING ON JUNE 27, 1997

To be added (Prof. R.N. Iyengar could not attend the meeting as he was abroad.)

P.5 e) Para iii) from top. The statement to be corrected as "..... by T. Paskalov or otherwise".

P.5 f) ii) The statement "The group decided that further work may not be done" is to be deleted.

Explanation: "If Paskalov's analysis could not be carried out any other applicable method may be used" is what I said. Infact the limitations of 2-D plane strain idealization (even after including the Canyon stiffening effect) is too glaring to be applicable in view of the arch-like plan of the dam, which was made known to the group only by 9-01-1998, udner this situation, any analysis done or suggested is only roughly indicative of the state of stress/strain/displacement as an aid for engineering judgement.

After iii) the following may be added

iv) Prof. R.N. Iyengar circulated brief extracts including the executive summary of the document "Safety of Dams: Flood and Earthquake criteria" (National Research Council, Washington DC 1985). He drew attention of the members to the main purpose of the group namely the **assessment of the seismic safety** of the current **design of the Tehri Dam.** Safety can only be quantified with **reference to a criterion.** The above document as well as the **ICOLD Guidelines** (Selecting Seismic Parameters for Large Dams) mention the criterion for safety under MCE as no **catastrophic release of water.** Hence estimation of stresses and depth of cracks along the length of the dam is necessary.

v) As per ICOLD norms **"New dams should be shown to be safe before being placed in service"** (Guidelines, p 11). This safety has to be evaluated taking into account the two components of risk present during earthquakes (ICOLD Guidelines p. 39) namely

(a) structural systems and components including the dam body.

(b) The socio-economic component consisting of down stream population.

The public perception and sentiment in the above evaluation (ICOLD guidelines p. 29) becomes important due to the fact the **risk is imposed and not voluntary**. The total risk factor as per ICOLD (i bid p. 39) would be 36, the highest possible risk state. (This includes the risk due to capacity, height, evacuation requirements and downstream damage). In this context the body of the dam, as per the present computations of DEQ-UOR, has been demonstrated to be robust. This is a necessary condtion for seismic safety, but not sufficient.

The reported response analysis of DEQ-UOR for the MCE accelerograms of Khattri *et. al* does not indicate very large permanent displacements. However, keeping in view the sensitivity of nonlinear behaviour, to possible variations in the values of parameters such as PGA, duration, frequency content and material properties, still larger displacements cannot be ruled out. Infact as per the Soviet Report (Tehri Dam Project on the Bhagirathi River, India, Contract No 53032/67652, 9, G, p. 73-74) to which attention was drawn by one member of the group, the dam section fail for the earthquake version with PGA-horiz=1.28g and PGA-vert=0.64g. Whereas there may be differences in the sections analyzed in the above report and the actual current design, attention is drawn to the fact that for some fortutious combination of inputs combined with particular reservoir-dam condtions, the performance of the dam to hold water at a future date may get affected. Thus, as a measure of abundant caution consequence analysis of a simulated dam breach has to be conducted.

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Shortcomings in Paskalov's method in so far as application to Tehri Section

i) **The method evaluates acceleration assuming linear behaviour. Under the very severe and highly improbable postulated earthquake time histories of Khattri, the dam would behave non-linearly and linear assumption is incorrect.**

ii) The method assumes a straight valley and a flat bed level. Tehri Dam is curved in plan and has a very undulating bed level.

iii) The method uses 1D modelling of the dam which is not applicable to the irregular 2D sections of the Tehri Dam.

iv) **The analysis assumes a rigid body behaviour of the sliding wedge which may be appropriate in small dams and not in case of tall dam like Tehri.**

v) There are some errors in the paper such as equations (2) and (12). Therefore, it does not give confidence in the implementation of the formulation in the computer code.

vi) In the practical example presented in the Paskalov's paper the trend of permanent displacement is incorrect.

vii) The steps of calculation of $\beta(t)$ and $\delta(t)$ in equation (12) are not clearly stated in the paper

viii) There are many possibilities for selecting the sliding wedge and the angles it makes with the horizontal which can give the maximum permanent displacement.

ix) Practically there is no guidance for selection of pore pressure coefficient and the internal friction mobilization coefficient.