National Committee on Seismic Design Parameters (NCSDP) for River Valley Projects

MINUTES OF 31st MEETING (23rd June, 2016)

Secretariat

Foundation Engineering & Special Analysis (FE&SA) Directorate
Central Water Commission
New Delhi

MINUTES OF THE 31ST MEETING OF
NATIONAL COMMITTEE ON SEISMIC DESIGN PARAMETERS FOR RIVER VALLEY PROJECTS
HELD ON 23RD JUNE, 2016 AT CWC, NEW DELHI

GENERAL

The 31st meeting of the National Committee on Seismic Design Parameters (NCSDP) for River Valley Projects was held on 23rd June, 2016, at Central Water Commission, New Delhi under the chairmanship of Sh. G. S. Jha, Member (D&R), CWC. The list of Members, invitees and project representatives who attended the meeting is given at ***Annexure I***.

Meeting commenced with Sh. G.S. Jha, Chairman, NCSDP welcoming the participants of the meeting followed by a brief introduction of the participants. Chairman mentioned that the earthquake is a very complex subject and it is very difficult to forecast an earthquake unlike flood, cyclone etc. He also mentioned that its analysis part requires a lot of experience. He mentioned that for uniformity in approach, there are guidelines for submission of the site specific seismic studies to the NCSDP. Further, he also emphasized on the time frame to carry out such studies so as to avoid delay, if any, in clearance of DPRs from appraisal point of view. Thereafter, Member Secretary, NCSDP was requested to take up the agenda items for discussion.

Before taking up the Agenda items for discussion, Member Secretary informed the Committee that as a follow up of the decision taken in the 30th meeting of NCSDP, a group meeting involving CWPRS, IIT Roorkee, IMD, NGRI and CWC was held on 31st May, 2016 under the chairmanship of Chief Engineer (DSO), CWC to discus and resolve the issues raised by CWPRS in previous meeting. Member Secretary further informed the Committee that main concern of CWPRS was the earthquake magnitude to be assigned to the Main Boundary Thrust (MBT). The issue raised by CWPRS was discussed in detail and following was decided:

"The potential of decollement be considered as magnitude 8.0 with appropriate distance for whole Himalayas unless reasons are given for lower potential. However, splays MBT/MCT may be assigned potential as per the practice of DSHA."

Further, Dr. B. R. K. Pillai, Chief Engineer (DSO), CWC informed the Committee that the issue of seismic instruments at DRIP dams location was also discussed in the group meeting and collaborations from Agencies i.e. IIT Roorkee, NGRI and CWPRS, for seismic

data collection, analysing and long term archiving was readily agreed. He also informed the Committee that MoU will be signed by the concerned agencies accordingly.

The minutes of the group meeting is given as ***Annexure-II***.

Item 31.1 CONFIRMATION OF THE MINUTES OF THE 30TH MEETING

Member Secretary informed the Committee that the Minutes of the 30th Meeting of NCSDP held on 15th September, 2015 were circulated to the Members of the Committee. He also informed that relevant extracts from the Minutes of Meeting were sent to the concerned project authority for information. He further informed that certain comments were received from CWPRS, which were deliberated in a meeting held jointly with CWPRS, IIT Roorkee, NGRI and IMD on 31st May, 2016. CWPRS representatives stated that with the clarification obtained in the meeting held on 31st May, 2016, they have agreed to the minutes of the meeting as circulated.

The Committee noted above and confirmed the Minutes of the 30th Meeting as circulated.

Further, it was also decided that that the Consultants (IIT Roorkee and CWPRS, Pune) for the site specific seismic studies currently under consideration of the Committee will incorporate the decision of group meeting held on 31st May, 2016 in the current studies and submit the revised seismic design parameters at the earliest. [*CWPRS, Pune submitted its compliance vide their letter no. 324/41/2015-ES dated 05.07.2016 (Annexure III) and IIT Roorkee has submitted its compliance vide their letter no. EQD/ dated 12.09.2016 (Annexure IV)].*

Item 31.2 AGENDA ITEMS CARRIED OVER FROM PREVIOUS MEETINGS

30.2.1 Conditionally cleared Projects - Submission of Micro Earthquake (MEQ) study

Member Secretary apprised the Committee that the site specific seismic study report of 10 projects was cleared in the previous meetings subject to submission of report on MEQ studies. In response, project authorities of 8 projects have requested for extension of time and no response has been received from the remaining two projects.

The issue was discussed and keeping the status of project/study in view, ***it was decided by the Committee that the extension of time for submission of the desired compliance may be given to the project authorities considering their request. The Committee was of the opinion that the time line given to the project authorities for submission of the***

requisite study report shall be adhered to. The Committee also decided that the project authorities who have not responded, shall submit their compliance by December, 2016.

31.2.2 Non-submission of site specific seismic study reports for NCSDP approval in respect of projects whose DPRs were conditionally cleared:

The Member Secretary apprised the Committee that till the previous meeting (30th), the compliance in respect of submission of site specific seismic studies from 10 projects was required to be submitted. Accordingly, reminders were issued to the concerned project authorities for submission of desired compliance. In response, two projects namely Nand Prayag Langasu HEP, Uttarakhand and Bunakha HEP, Bhutan have submitted the site specific seismic study report and the same have been included in the Agenda items of this meeting under Item nos. 31.3.8 and 31.3.10 respectively. The desired compliance from remaining 8 projects is yet to be submitted. Out of which, project authorities of 5 projects (including late receipt of responses from Talong Londa HEP, Arunachal Pradesh and Chhatru HEP, Himachal Pradesh) have requested for extension of time and the response from 2 projects is still awaited. The project authority of Demwe Upper H E Project, Arunachal Pradesh vide their letter of even no. dated 20.06.2016 informed that DPR of the project has been treated as returned by CEA due to non-finalization of type of dam. Accordingly, project authorities have indicated that the site specific seismic studies would be done only after finalization of project parameters/dam type and the same will be submitted for approval of NCSDP.

The issue was discussed and keeping the status of project/study in view, ***it was decided by the Committee that the extension of time for submission of the desired compliance may be given to the project authorities considering their request. The Committee also decided that the project authorities who have not responded, shall submit their compliance by December, 2016. Further, the Committee was also of the view that the Demwe Upper H E Project, Arunachal may be delisted from the pending compliance list considering the status of its DPR.***

Item 31.3 PROJECTS CONSIDERED FOR APPROVAL OF THE COMMITTEE

Based on the decisions under Item 31.1 above, the study reports have been revised by CWPRS, Pune and IIT, Roorkee; and submitted their compliance vide letter no. *324/41/2015-ES dated 05.07.2016* ***(Annexure III)*** and EQD/ dated 12.09.2016 (***Annexure IV***) respectively.

Further, before start of the presentation by the project authorities, the issue of the acceptance of studies carried out by the individual expert(s) for consideration of the Committee was raised. In response, Member Secretary informed the Committee that in the 28th meeting held on 9th January, 2015, the matter was discussed in detail and it was agreed to decide these matters on case to case basis. Accordingly, in that meeting (28th), the study report of P V Narasimha Rao Kanthanapally Sujala Sravanthi Project, Telangana State carried out by Dr I D Gupta (Ex. Director, CWPRS) in individual capacity was considered by the Committee for approval. In this meeting, the matter was discussed again and the Committee was of the opinion that the selection of the consultant is the domain of Project authorities and we should accept or reject the study based on its merit. The deficiencies in such report(s) should be indicated and project authorities may be asked for its re-submission after incorporating the requisite compliance. Accordingly, the study reports of the Morand and Ganjal Dam carried out by Dr I D Gupta (Ex. Director, CWPRS) in individual capacity which are placed at Agenda of this meeting under item no 31.3.2 and 31.3.3 respectively, have been accepted for consideration of the Committee for its approval.

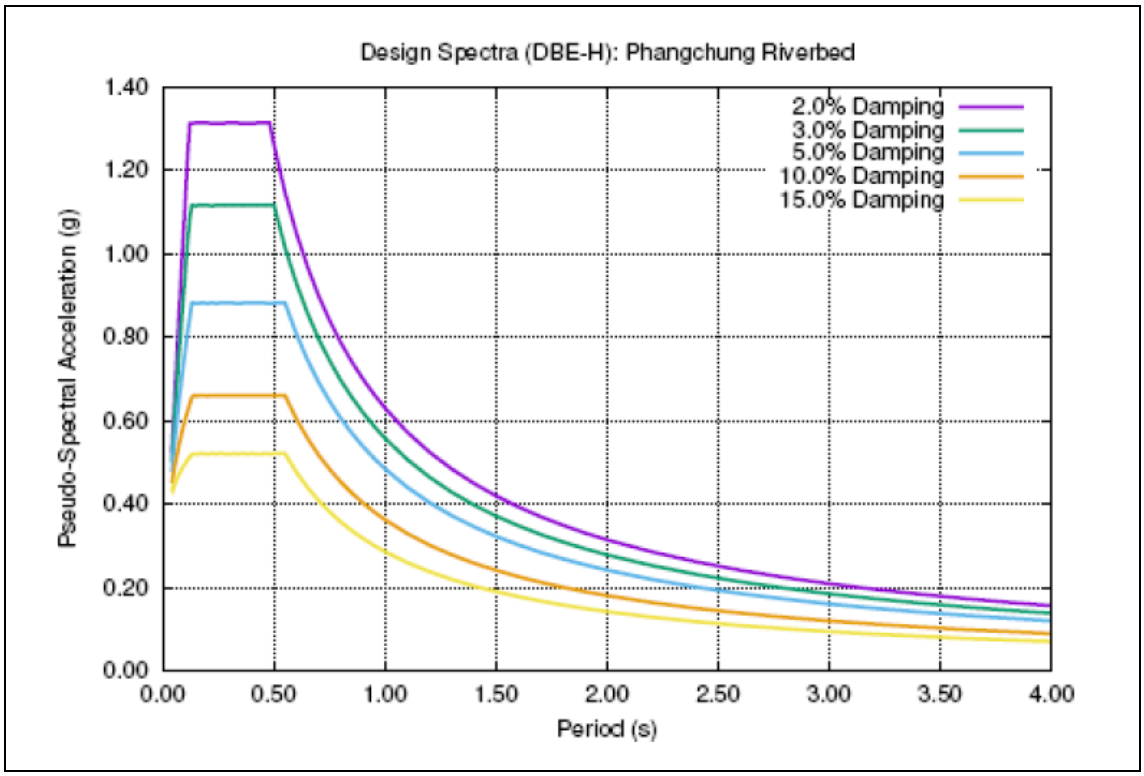
Further, the Committee also felt for review of the NCSDP guidelines so as to incorporate new insights/developments in the subject matter. Accordingly, it was decided that Chairman (NCSDP) will constitute a sub-Committee to update the guidelines accordingly.

31.3.1 Phanchung Hydro Electric Project, Arunachal Pradesh

A presentation on the study report was made by the project authorities.

After brief deliberation, the Committee accorded approval to the study report of Phanchung H.E. Project, Arunachal Pradesh incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1. The summarized seismic design parameters of the approved report are as under:

(a) Response Spectra



(b) Other seismic parameters

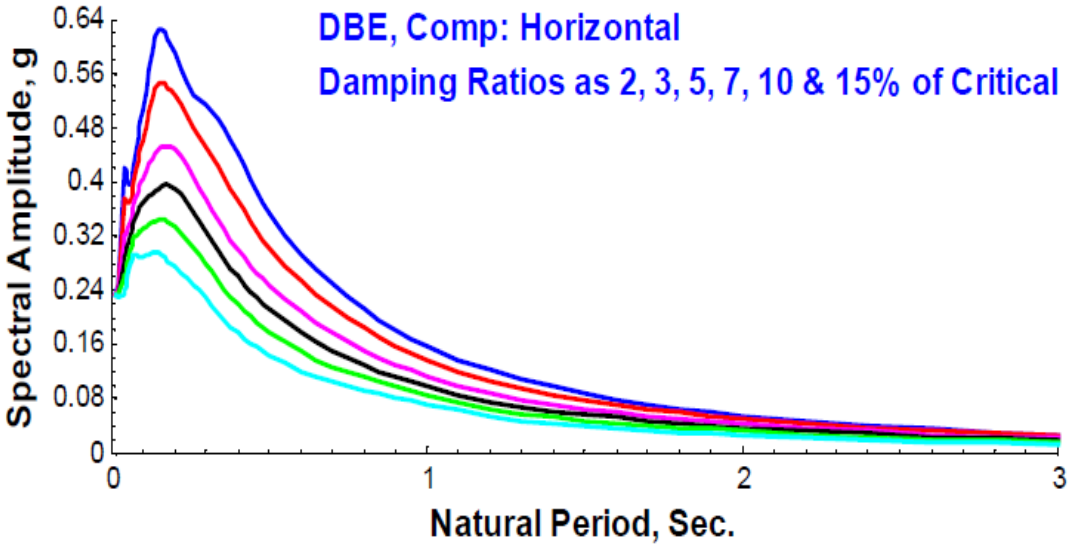
Max. Credible Earthquake Magnitude	8	Horizontal distance to surface projection of fault (R_{JB}) (km)	5	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.24	Vertical seismic co-efficient (α_v)	0.16		
Strong motion duration (second)	8 (at bed rock level) 13 (at river bed level)	Total duration (second)	42 (at bed rock level) 65 (at river bed level)		
Report reference	IIT Roorkee Report (EQ: 2014-03 (M); Project No. EQD-6017/13-14 (November-2015)]				

31.3.2 Morand Dam Project, Madhya Pradesh

A presentation on the study report was made by the project authorities. During discussion, it was suggested by Sh. Niroj Sarkar, GSI that we may include the shear wave velocity parameters considered in the study as part of the report itself. Some of the Committee Members were of the view that suggestion may be incorporated in the guidelines while reviewing, which was agreed by all.

After brief deliberation, the Committee accorded approval to the study report of Morand Dam Project, Madhya Pradesh. The summarized seismic design parameters of the approved report are as under:

(a) Response Spectra



Design response spectra (DBE)

(b) Other seismic parameters

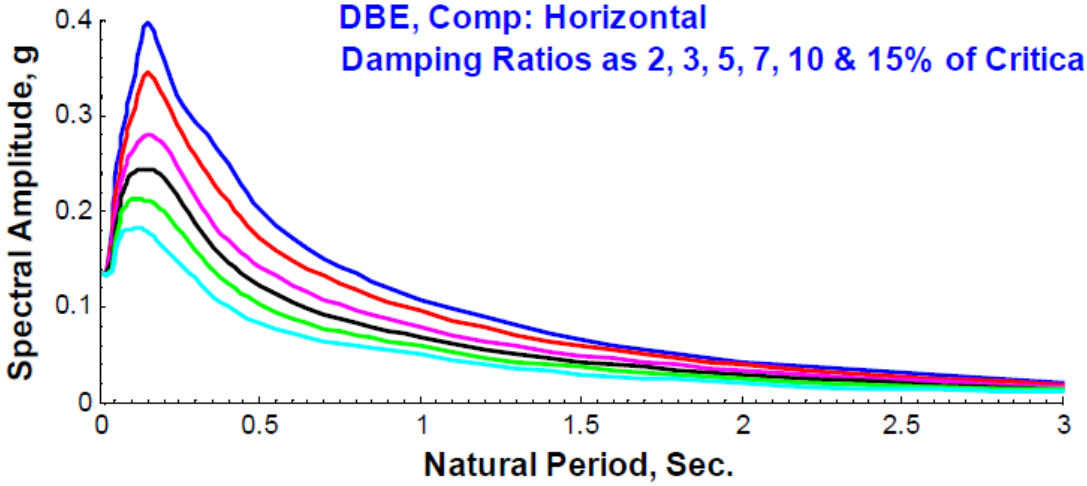
Max. Credible Earthquake Magnitude	6.5	Closest distance from fault rupture plane (km)	15.9	Focal depth km)	20
Horizontal seismic co-efficient (α_h)	0.12		Vertical seismic co-efficient (α_v)		0.08
Strong motion duration (second)	6.78 (say 7 sec)		Total duration (second)		36
Report reference	Dr. I D Gupta (Ex. Director CWPRS, Pune)'s Report of August, 2015				

31.3.3 Ganjal Dam Project, Madhya Pradesh

A presentation on the study report was made by the project authorities.

After brief deliberation, the Committee accorded approval to the study report of Ganjal Dam Project, Madhya Pradesh. The summarized seismic design parameters of the approved report are as under:

(a) Response Spectra



Design response spectra (DBE)

(b) Other seismic parameters

Max. Credible Earthquake Magnitude	6.5	Closest distance from fault rupture plane (km)	16	Focal depth km)	20
Horizontal seismic co-efficient (α_h)	0.12		Vertical seismic co-efficient (α_v)		0.08
Strong motion duration (second)	6.78 (say 7 sec)		Total duration (second)		41
Report reference	Dr. I D Gupta (Ex. Director CWPRS, Pune)'s Report of August, 2015				

31.3.4 Kwar Hydro Electric Project, Jammu & Kashmir

A presentation on the study report was made by the project authorities. During the presentation the project authorities have circulated the MEQ studies carried out by Wadia Institute of Himalayan Geology, Dehradun for 109.0 m high concrete dam. In response, IIT Roorkee has made following observations on the report submitted on MEQ studies of Kiru, Kwar and Pakal Dul HE projects:

1. The array used for acquiring the MEQ data from the three projects is not well designed. All the stations are on southern side of Pakal Dul with only one station on the dam site itself. Similarly, the stations are falling on the SW of the projects Kiru and Kwar. The array may not cover spatially the MEQs occurring in the vicinity of these dam sites from the point of view of estimating the depths.

2. The objective of the study as given in the report are not falling in line with the objectives with which these studies are supposed to be carried out.

3. The seismicity as reported by IMD is shown to have magnitude ranges 1-2, 2-3, 3-4, 4-5 and 5-6, however, the Table is not representing the statement made in the text. There are no earthquakes less than 3 (which are called as microearthquakes) reported in the table 2 of the report which also is not required in such reports.

4. Please attach the Sushil, (2016) unpublished report as annexure to this report.

5. No justification has been given as to why only 13 earthquakes are located as given in Table 6, 14 are located as given in Table 7 while 178 events are reported to be recorded by the array.

6. No microearthquakes have been reported in this report in such a seismically active region.

7. The report is badly written without understanding of objectives with which these microearthquake networks are to be deployed around HE projects for six months.

8. Fig 31, 32 and 33 are not relevant and serves no purpose.

9. The discussion and conclusions section says that total 13 earthquakes have been recorded during the six months period in the 50 km radius from the centre of Kiru, Kwar and Pakal dul project sites. These are not microearthquakes.

Further, CWPRS has also made the following observations on the MEQ study report:

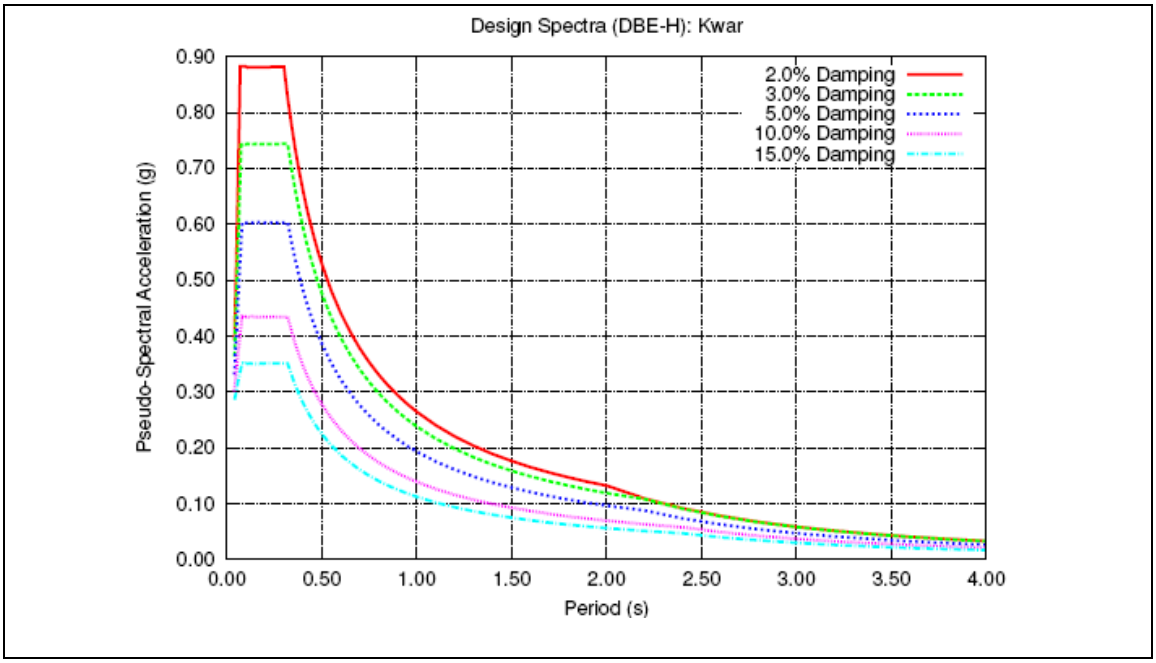
1. It is not given in the report that the computation of the magnitude and location of the events have been done using the software SEISAN, it could be elaborated a little more by giving the formulae used.

2. Since the study is on microearthquakes the events with magnitude greater than or equal to 1.0 need to be mentioned in Table 9.

During presentation, Dr. P.K. Champati Ray, IIRS stated that there should be some guidelines for carrying out the MEQ studies. Some of the Committee Members were of the view that the suggestion may be taken care of while reviewing the NCSDP guidelines, which was agreed by all.

After brief deliberation, the Committee accorded approval to the study report of Kwar H E Project, Jammu & Kashmir incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 and as summarized below. The Committee also noted that its approval is conditional subject to the submission of revised/updated MEQ studies report incorporating the compliance to the observations of the Committee by the project authorities by June, 2017.

(a) Response Spectra



(b) Other seismic parameters

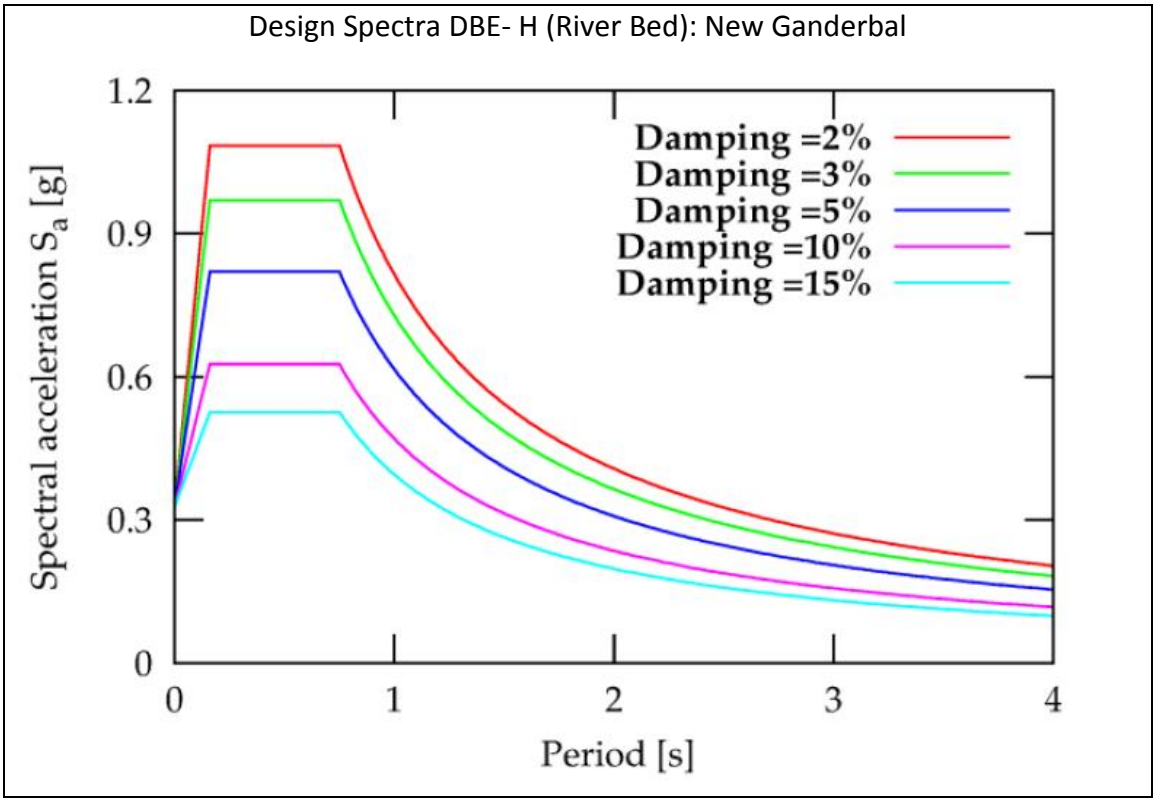
Max. Credible Earthquake Magnitude	8	Horizontal distance to surface projection of fault (R_{JB}) (km)	5	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.16	Vertical seismic co-efficient (α_v)	0.11		
Strong motion duration (second)	8	Total duration (second)	42		
Report Reference	IIT Roorkee Report (EQ: 2015-12 (M); Project No. 6027/2014-15 (August-2015)]				

31.3.5 New Ganderbal Hydro Electric Project, Jammu & Kashmir

A presentation on the study report was made by the project authorities.

After brief deliberation, the Committee accorded approval to the study report of New Ganderbal H E Project, Jammu & Kashmir incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 and as summarized below:

(a) Response Spectra



(b) Other seismic parameters

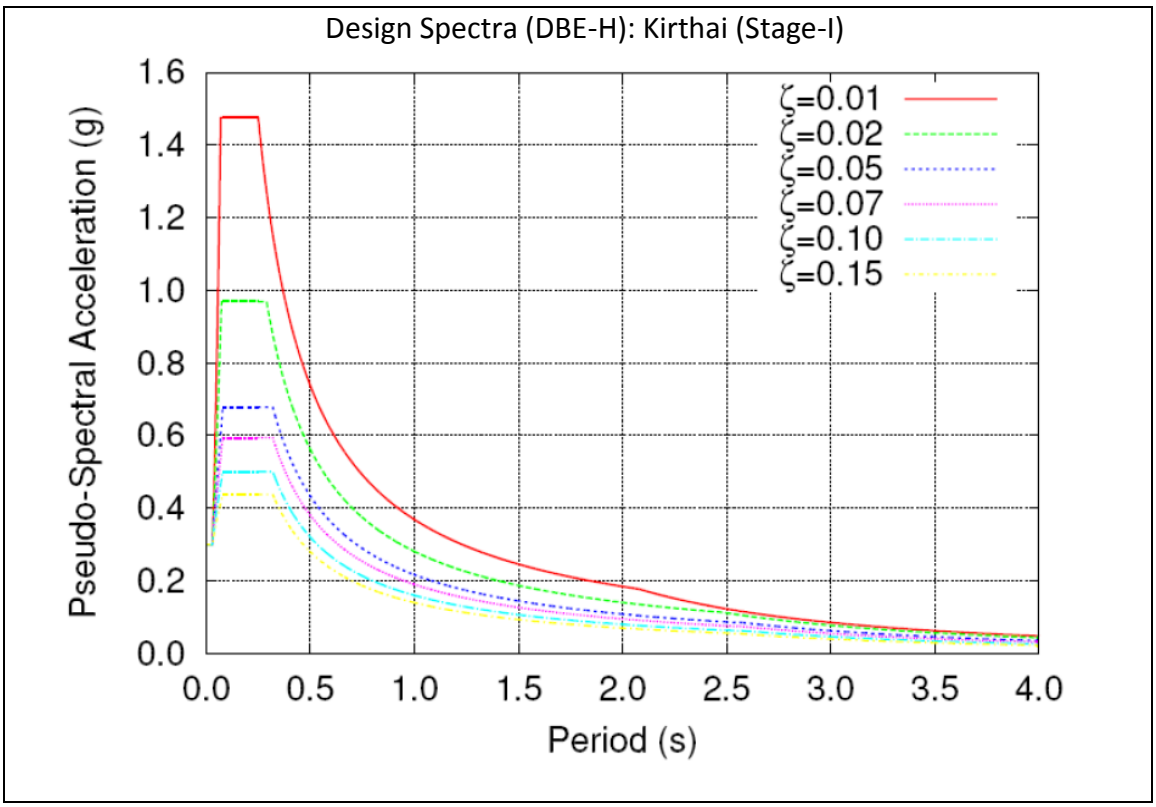
Max. Credible Earthquake Magnitude	8	Horizontal distance to surface projection of fault (R_{JB}) (km)	5	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.24	Vertical seismic co-efficient (α_v)	0.16		
Strong motion duration (second)	8 (at bed rock level) 23 (at river bed level)	Total duration (second)	42 (at bed rock level) 120 (at river bed level)		
Report Reference	IIT Roorkee Report (EQ: 2014-25 (M1); Project No. EQD-6012/14-15 (August -2015)]				

31.3.6 Kirthai Hydro Electric Project (Stage-I), Jammu & Kashmir

A presentation on the study report was made by the project authorities. The project authorities informed that MEQ studies for 165 m high RCC dam will be taken up shortly and final study report will be submitted by June, 2017.

After brief deliberation, the Committee accorded approval to the study report of Kirthai H E Project (Stage-I), Jammu & Kashmir incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 and as summarized below. The Committee also noted that its approval is conditional subject to the submission of MEQ studies by the project authorities by June, 2017.

(a) Response Spectra



(b) Other seismic parameters

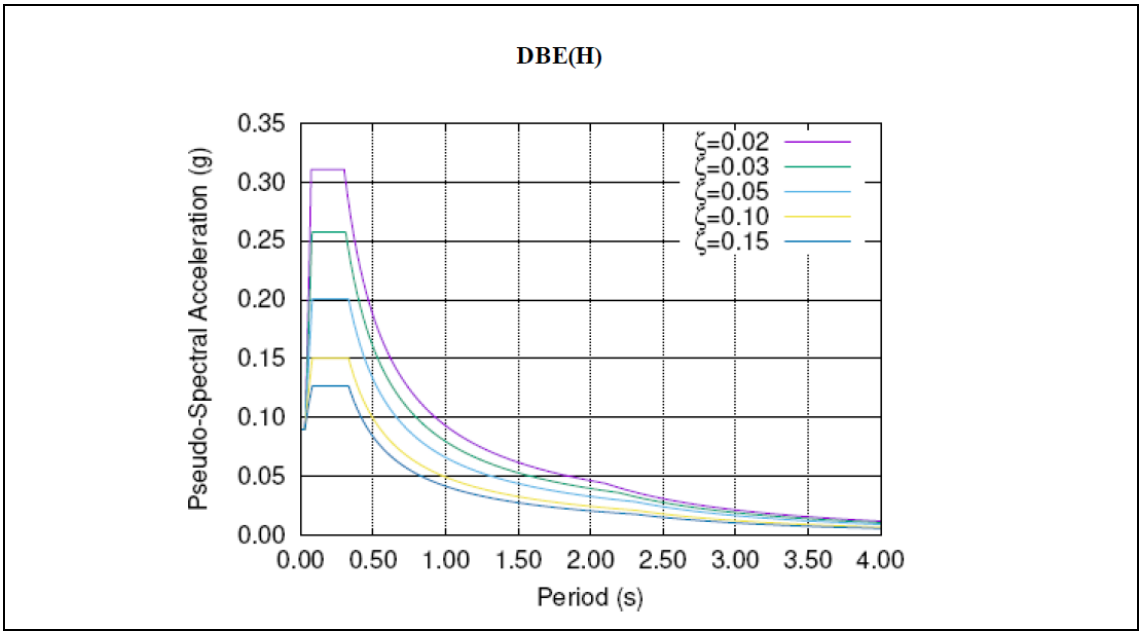
Max. Credible Earthquake Magnitude	8	Horizontal distance to surface projection of fault (R_{JB}) (km)	5	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.18	Vertical seismic co-efficient (α_v)	0.12		
Strong motion duration (second)	9	Total duration (second)	45		
Report Reference	IIT Roorkee Report (EQ: 2014-22(M); Project No. EQD-6032/12-13 (December -2015)]				

31.3.7 Hiramandalam Reservoir of B.R.R. Vamsadhara Project, Phase-II of Stage-II, Andhra Pradesh

A presentation on the study report was made by the project authorities. During the meeting, it was discussed that for the low seismicity regions (Seismic Zones II and III as per IS:1893-2002), the recurrence interval of MCE level earthquakes is very large and therefore the MCE target spectrum for project sites in these regions is to be taken as median estimates as per the NCSDP guidelines. This is to maintain approximately uniform level of seismic risk across the entire country. Accordingly, the MCE and DBE estimates for Vamsdhara project site, which lies in low seismicity area (Zone II), to be modified as per the NCSDP guidelines and the representatives for IIT Roorkee agreed for the same. The revised seismic design parameters has been supplied by the IIT Roorkee vide their letter no. EQD/dated 12.09.2016 (***Annexure IV***).

After brief deliberation, the Committee accorded approval to the study report of Hiramandalam Reservoir of B.R.R. Vamsadhara Project, Phase-II of Stage-II, Andhra Pradesh incorporating the revised seismic design parameters arrived as per Committee's decisions and as summarized below:

(a) Response Spectra



(b) Other seismic parameters

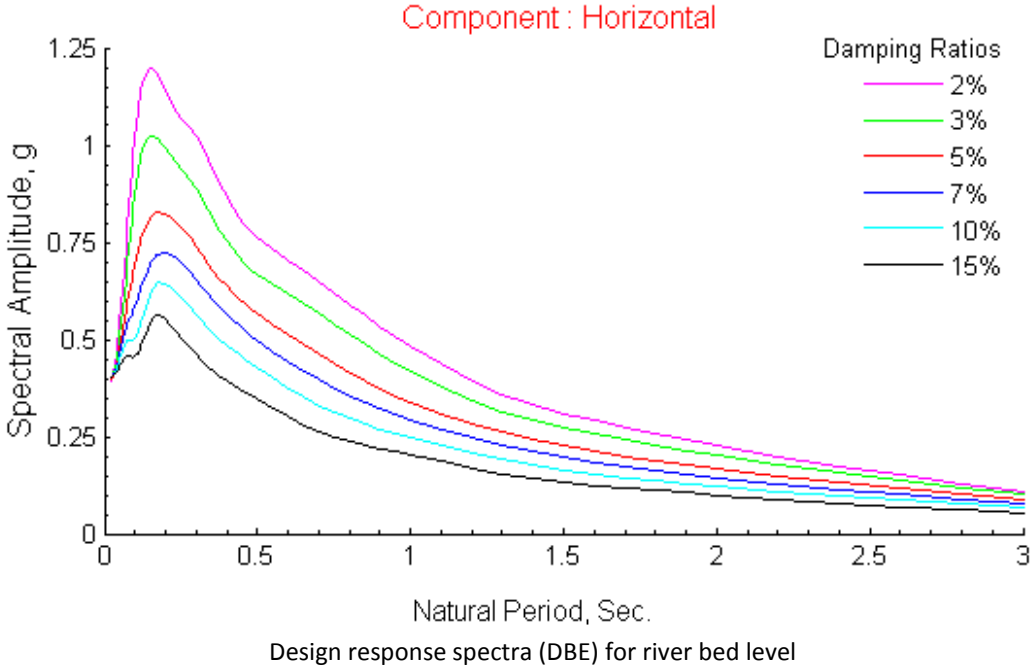
Max. Credible Earthquake Magnitude	6.0	Horizontal distance to surface projection of fault (R_{JB}) (km)	0	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.06		Vertical seismic co-efficient (α_v)		0.04
Strong motion duration (second)	9		Total duration (second)		49
Report Reference	IIT Roorkee Report (EQ: 2016-02 (M); Project No. EQD-6010/15-16 (January-2016)				

31.3.8 Nand Prayag Langasu Hydro Electric Project, Uttarakhand

A presentation on the study report was made by the project authorities.

After brief deliberation, the Committee accorded approval to the study report of Nand Prayag Langasu H E Project, Uttarakhand incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 and as summarized below:

(a) Response Spectra



Design response spectra (DBE) for river bed level

(b) Other seismic parameters

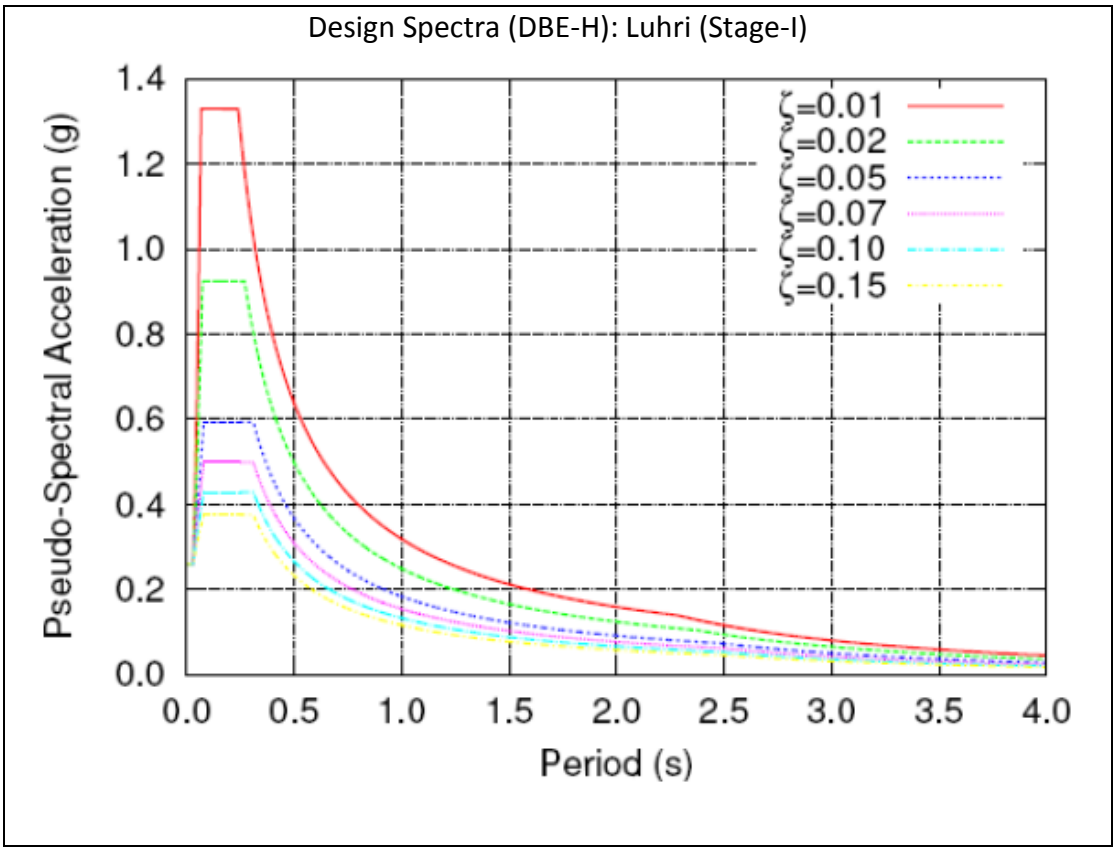
Max. Credible Earthquake Magnitude	8	Closest distance from the site (R_{JB}) (km)	5	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.24	Vertical seismic co-efficient (α_v)	0.16		
Strong motion duration (second)	6 (at rock outcrop level) 9 (at river bed level)	Total duration (second)	42 (at rock outcrop level) 48 (at river bed level)		
Report Reference	CWPRS Report [(Technical Report No. 5326 (October -2015)]				

31.3.9 Luhri Hydro Electric Project (Stage-I), Himachal Pradesh

A presentation on the study report was made by the project authorities.

After brief deliberation, the Committee accorded approval to the study report of Luhri Hydro Electric Project (Stage-I), Himachal Pradesh incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 and as summarized below:

(a) Response Spectra



(b) Other seismic parameters

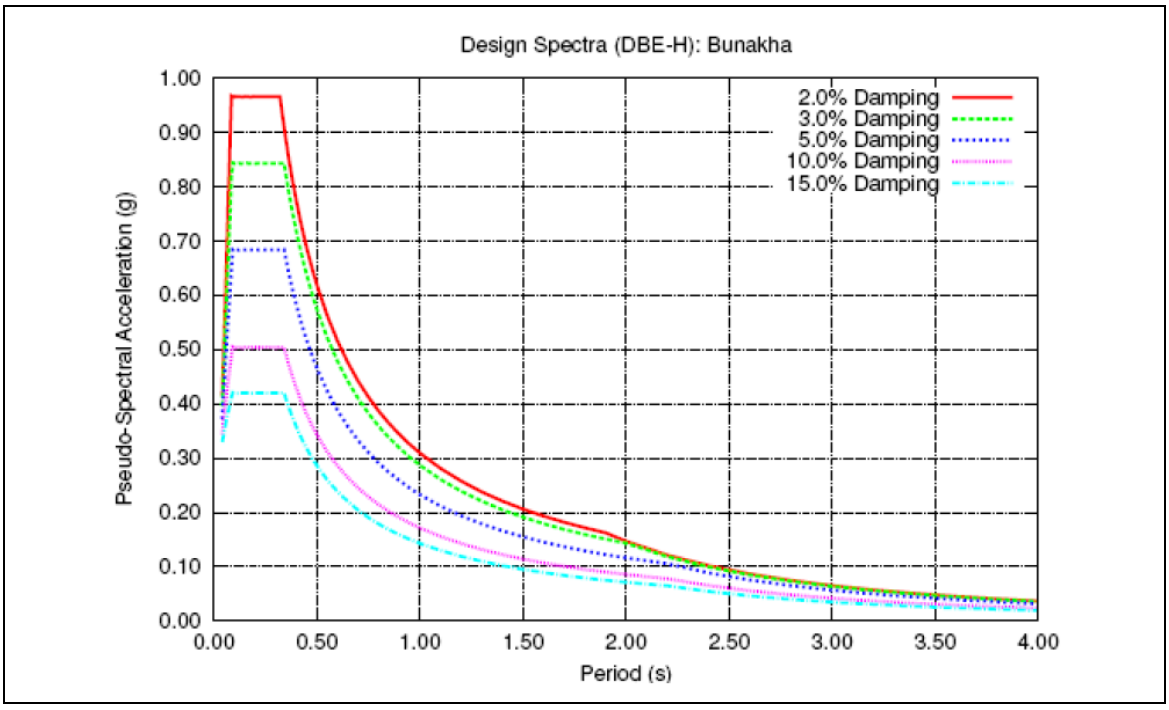
Max. Credible Earthquake Magnitude	8	Horizontal distance to surface projection of fault (R_{JB}) (km)	5	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.24	Vertical seismic co-efficient (α_v)	0.16		
Strong motion duration (second)	8	Total duration (second)	43		
Report Reference	IIT Roorkee Report (EQ: 2014-30 (M2); Project No. EQD-6005/13-14 (October-2015)				

31.3.10 Bunakha Hydro Electric Project, Bhutan

A presentation on the study report was made by the project authorities. The project authorities have informed that seismological studies have been carried out by CWPRS for the period October 2010 to May 2011. Dr M.L. Sharma, IIT Roorkee mentioned that the records of seismicity collected from only three micro earthquake recording stations for the period October 2010 to May 2011, which is not sufficient. In view of this, it was decided that fresh MEQ studies for 197 m concrete dam need to be taken up and final report shall be submitted by June, 2017.

After brief deliberation, the Committee accorded approval to the study report of Bunakha Hydro Electric Project, Bhutan incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 and as summarized below. The Committee also noted that its approval is conditional subject to the submission of MEQ studies by the project authorities by June, 2017.

(a) Response Spectra



(b) Other seismic parameters

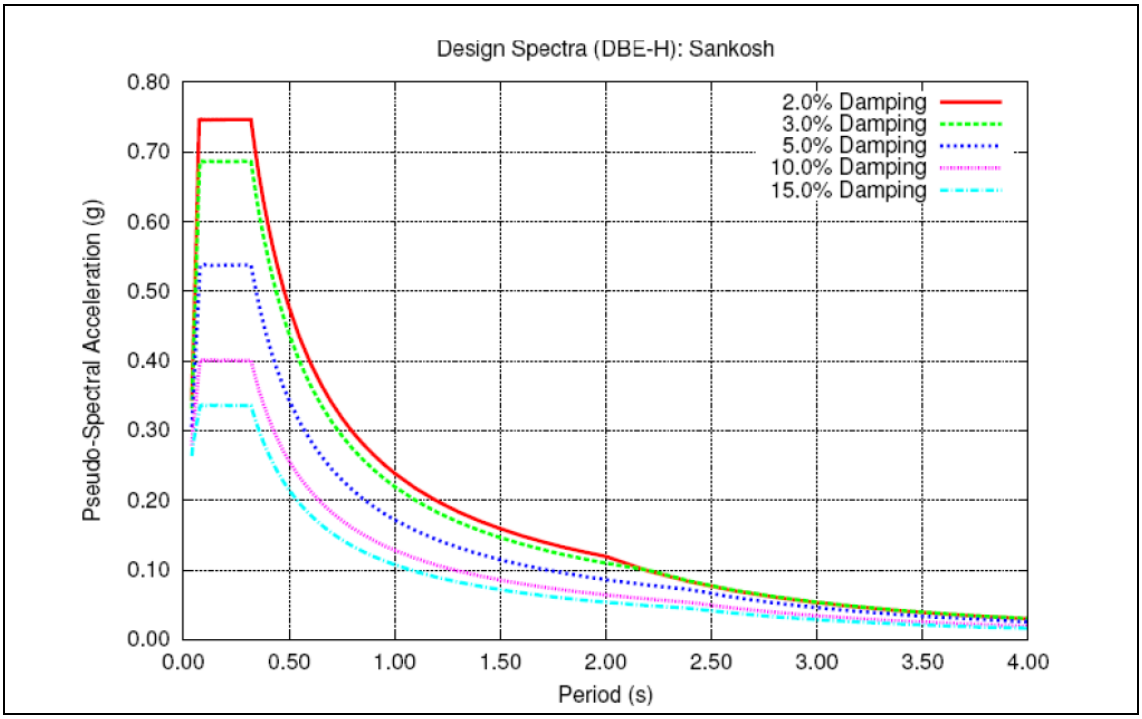
Max. Credible Earthquake Magnitude	8	Horizontal distance to surface projection of fault (R_{JB}) (km)	5	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.24	Vertical seismic co-efficient (α_v)	0.16		
Strong motion duration (second)	9	Total duration (second)	48		
Report Reference	IIT Roorkee Report (EQ: 2009-26(M); Project No. EQD-1004/09-10 (March-2016)				

31.3.11 Sankosh Hydro Electric Project, Bhutan

A presentation on the study report was made by the project authorities. The project authorities have informed that MEQ and LET/MT studies for 235 m concrete dam will be taken up shortly and final study report will be submitted by June, 2017.

After brief deliberation, the Committee accorded approval to the study report of Sankosh H E Project, Bhutan incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 and as summarized below. The Committee also noted that its approval is conditional subject to the submission of MEQ and LET/MT studies by the project authorities by June, 2017.

(a) Response Spectra



(b) Other seismic parameters

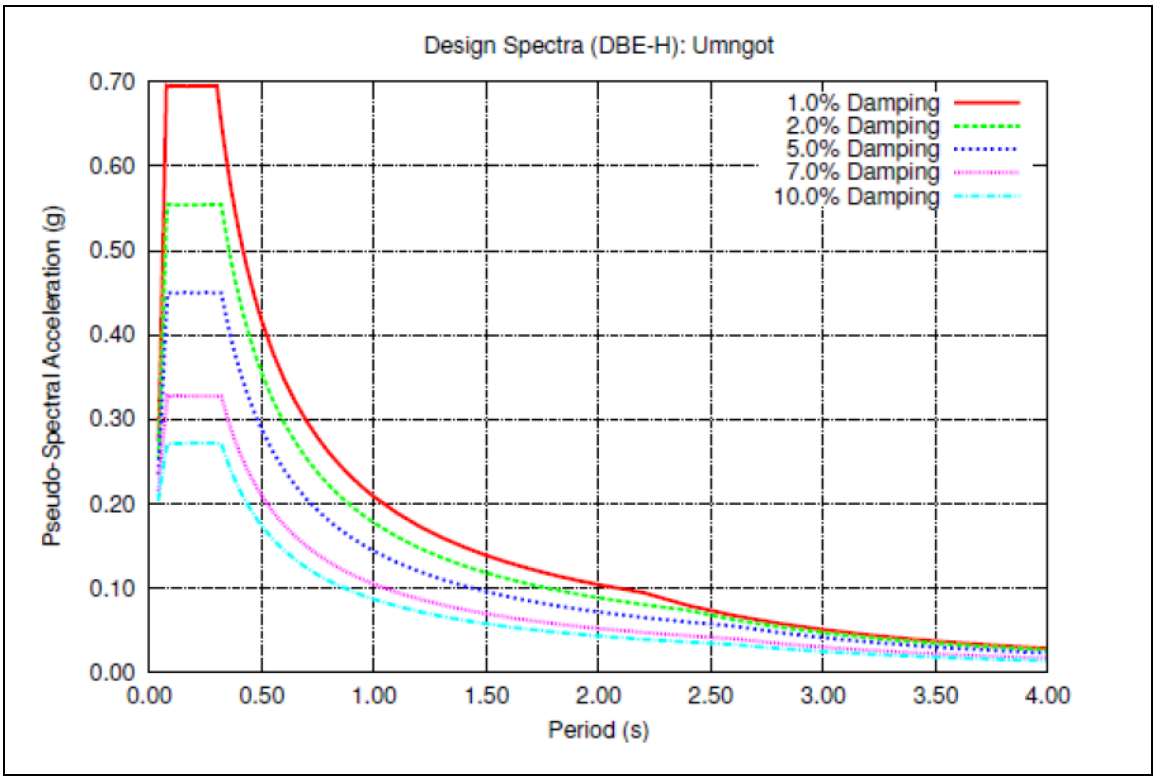
Max. Credible Earthquake Magnitude	8	Horizontal distance to surface projection of fault (R_{JB}) (km)	5	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)		0.24	Vertical seismic co-efficient (α_v)		0.16
Strong motion duration (second)		8	Total duration (second)		43
Report Reference		IIT Roorkee Report (EQ: 2016(M); Project No. EQD- 6045/15-16 (March-2016)			

31.3.12 Umngot Hydro Electric Project, Meghalaya

A presentation on the study report was made by the project authorities. The project authorities have informed that MEQ studies for 111 m concrete dam will be taken up shortly and final study report will be submitted by June, 2017.

After brief deliberation, the Committee accorded approval to the study report of Umngot H E Project, Meghalaya incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 and as summarized below. The Committee also noted that its approval is conditional subject to the submission of MEQ studies by the project authorities by June, 2017.

(a) Response Spectra



(b) Other seismic parameters

Max. Credible Earthquake Magnitude	8.0	Horizontal distance to surface projection of fault (R_{JB}) (km)	22	Focal depth (km)	15
Horizontal seismic co-efficient (α_h)	0.24	Vertical seismic co-efficient (α_v)	0.16		
Strong motion duration (second)	10	Total duration (second)	55		
Report Reference	IIT Roorkee Report (EQ: 2014-35(M); Project No. EQD- 6008/13-14 (November-2015)				

31.3.13 Pancheshwar Multipurpose Project, India-Nepal

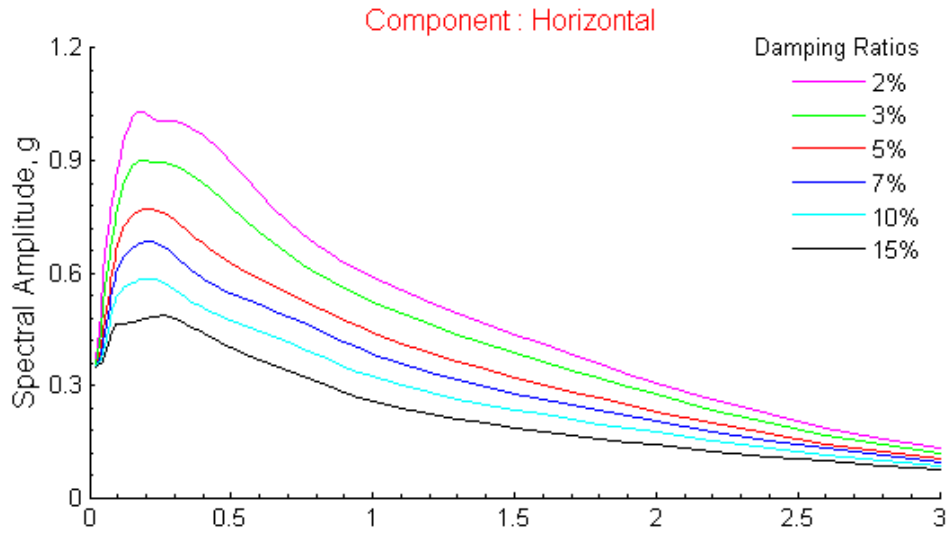
A presentation on the study report was made by the project authorities. The project authorities have informed that MEQ studies for 315 m high dam will be taken up. On a specific query about the type of dam, it was informed by the project authorities that the study has been carried out for rock-fill dam but the concrete dam option is also under active consideration and can not be ruled out. Accordingly, it was requested to CWPRS (the consultant) to update/revise the study by incorporating the study results in respect of seismic design parameters for concrete dam option also and furnish the seismic design parameters for both the cases in the report. CWPRS agreed for the updation and submission of the study report accordingly. The CWPRS has revised/updated the study report as per Committee's decisions under item 31.1 and incorporated the study results in respect of seismic design parameters for concrete dam option as well. The updated/revised report has been submitted by CWPRS vide their letter dated 05.07.2016. ***(Annexure-III).***

Dr. D. Srinagesh, NGRI mentioned that GPS studies also need to be undertaken in the vicinity of the dam to understand the rate of the deformation. Also, INSAR studies should be explored to understand the deformation by complimentary technique with the help of IIRS (ISRO). Further Dr. M. L. Sharma, IIT Roorkee was of the view that continuous monitoring is required through array of permanent stations to record the earthquakes. At least 12 stations should be deployed with instruments like broadband, short period and strong motion accelerograms.

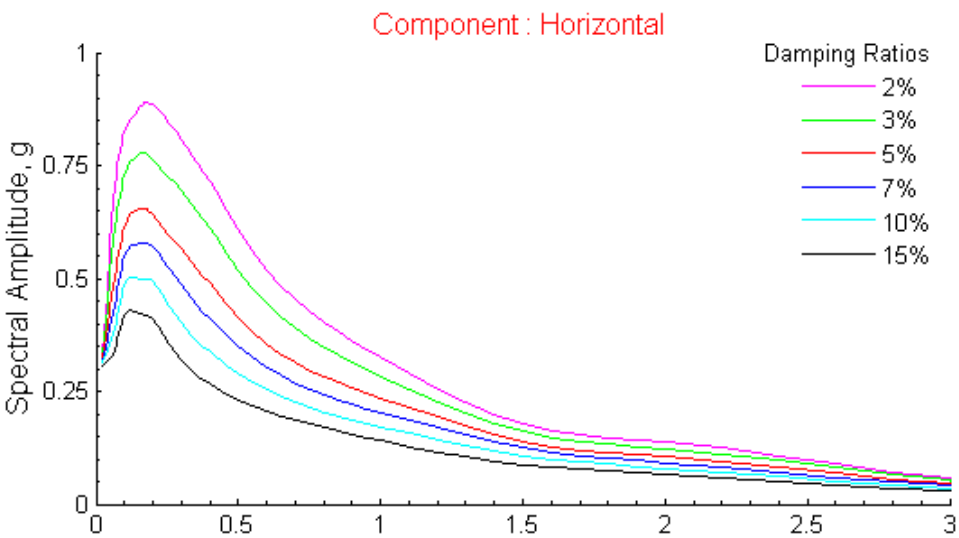
Keeping in view of the status and volume of further studies as suggested, it was decided by the Committee to give two years of time (i.e. June, 2018) to project authorities for carrying out the MEQ and other requisite studies and submission of final report to NCSDP for consideration.

After detailed deliberation, the Committee accorded approval to the study report of Pancheshwar Multipurpose Project, India-Nepal incorporating the revised seismic design parameters arrived as per Committee's decisions under item 31.1 along with study results for concrete dam option as well. The Committee also noted that its approval is conditional subject to the submission of MEQ studies, LET/MT/GPS studies *and progress on permanent deployment of 12 station array around the site* by the project authorities by June, 2018. The summarized seismic design parameters of the approved report are as under:

(a) Response Spectra



Design response spectra (DBE)
(For ROCK-FILL DAM)



Design response spectra (DBE)
(For CONCRETE DAM)

(b) Other seismic parameters

Max. Credible Earthquake Magnitude	8.0	Closest distance from the fault rupture plane (km)		17.5
Horizontal seismic co-efficient (α_h)	0.24	Vertical seismic co-efficient (α_v)		0.16
Strong motion duration (second) (For Rockfill dam)	8	Total duration (second) (For Rockfill dam)		45.4
Strong motion duration (second) (For Concrete dam)	6	Total duration (second) (For Concrete dam)		42
Report Reference	Modified CWPRS Report (Technical Report No. 5311 (August, 2015]			

31.4 Site specific seismic parameters for Dam Rehabilitation Improvement Project (DRIP) dams

Member Secretary requested representatives of IIT Roorkee to brief the Committee about the status of the site specific seismic parameters for DRIP Dams. Dr. M. L. Sharma, IIT stated that the work of seismic hazard Assessment study (South India region) was awarded to IIT Roorkee by the Central Water Commission in March, 2016. He also informed the Committee that the study is under progress and will be completed in a time period of 18 months.

Further, Dr B R K Pillai, Chief Engineer (DSO), CWC informed the Committee that in the process of finalization of agency for carrying out the seismic hazard Assessment study (South India region) for DRIP dams, Ministry of Water Resources, RD &GR desired that CWPRS, Pune should also contribute in such studies. Since, the study for South India Region has already been awarded to IIT Roorkee, it has been suggested that CWPRS, Pune may also submit their proposal for carrying out such studies for other regions in India for DRIP and other dams for consideration.

The Committee noted above.

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The meeting ended with vote of thanks to the chair.

Summary of Policy related decisions of 31st NCSDP meeting:

- A Sub-Committee for review of NCSDP Guidelines is to be constituted. *(Item 31.3)*

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Central Dam Safety Organisation

National Committee on Seismic Design Parameters (NCSDP)

31st Meeting

Summary of the Decisions Taken at the Meeting

Date of Meeting:	23.06.2016	Time:	11:00 h to 18:00 h	Venue:	Conference Room, 525(N), Sewa Bhawan, R K Puram, New Delhi-66
Present					
Chairperson:	Sh. G. S. Jha, Member (D&R), CWC			Member Secretary:	Sh. O. P. Gupta Director (FE&SA), CWC
Other Members and special Invitees, (Name, Designation, Organization): A List of participants is placed at ***Annexure-I***					

Item no.	Agenda Points / Decision	Responsibility	Achievement/ Progress	Remarks
31.1	Confirmation of the Minutes of the 30th meeting	-	Confirmed	-
31.2	Agenda items carried over from the previous meetings			
31.2.1	Conditionally cleared Projects - Submission of Micro Earthquake (MEQ) study	Concerned project authorities	Discussed and decided	-
31.2.2	Non-Submission of site specific seismic study reports for NCSDP approval in respect of projects whose DPRs were conditionally cleared	Concerned project authorities	Discussed and decided	-
31.3	Projects to be considered for approval of the Committee			
31.3.1	Phanchung Hydro Electric Project, Arunachal Pradesh	-	cleared	-
31.3.2	Morand Dam Project, Madhya Pradesh	-	Cleared	-
31.3.3	Ganjal Dam Project, Madhya Pradesh	-	Cleared	-
31.3.4	Kwar Hydro Electric Project, Jammu & Kashmir	Concerned project authorities	Conditional clearance	Updated MEQ studies to be submitted by June, 2017
31.3.5	New Ganderbal Hydro Electric Project, Jammu & Kashmir	-	cleared	-
31.3.6	Kirthai Hydro Electric Project (Stage-I), Jammu & Kashmir	Concerned Project Authorities	Conditional clearance	MEQ studies to be submitted by June, 2017
31.3.7	Hiramandalam Reservoir of B.R.R. Vamsadhara Project, Phase-II of Stage-II, Andhra Pradesh	-	Cleared	-

Item no.	Agenda Points / Decision	Responsibility	Achievement/ Progress	Remarks
31.3.8	Nand Prayag Langasu Hydro Electric Project, Uttarakhand	-	Cleared	-
31.3.9	Luhri Hydro Electric Project (Stage-I), Himachal Pradesh	-	Cleared	-
31.3.10	Bunakha Hydro Electric Project , Bhutan	Concerned Project Authorities	Conditional clearance	MEQ studies to be submitted by June, 2017
31.3.11	Sankosh Hydro Electric Project , Bhutan	Concerned Project Authorities	Conditional clearance	MEQ and LET/MT studies to be submitted by June, 2017
31.3.12	Umngot Hydro Electric Project , Meghalaya	Concerned Project Authorities	Conditional clearance	MEQ studies to be submitted by June, 2017
31.3.13	Pancheshwar Multi Purpose Project, India-Nepal	Concerned Project Authorities	Conditional clearance	MEQ and LET/MT /GPS studies to be submitted by June, 2018
30.4	Site specific seismic parameters for Dam Rehabilitation Improvement Project (DRIP) dams	Informative	-	-

Annexure –I

31st Meeting of National Committee on Seismic Design Parameters (NCSDP) on River Valley Projects

List of Participants on 23.06.2016

Sl. No.	Name & Address	Designation	Deptt./Org.	Status/ Representative
I. Committee Members				
1.	Sh. G.S. Jha	Member (D&R)	CWC, New Delhi	Chairman, NCSDP
2.	Dr. B. R. K. Pillai	Chief Engineer (DSO)	CWC, New Delhi	Member
3.	Dr. Yogendra Singh	Professor & Head Deptt. of Earthquake Engg.	DEQ, IIT Roorkee,	Member
4.	Dr. P.K. Champati Ray	Group Head, Geo Science and Disaster management studies	Indian remote sensing (IIRS), Dehradun	Member
5.	Dr. D. Srinagesh	Head, Seismology Observatory, Chief Scientist, CSIR	NGRI, Hyderabad	Representative of NGRI
6.	Dr. P. R. Baidya	Scientist 'E'	National Centre for Seismology, IMD, New Delhi	Representative of IMD
7	Sh. Niroj Kumar Sarkar	Director (Geology)	Geological Survey of India (GSI), Kolkata	Representative of GSI
8.	Sh. Rajiv Kumar Srivastava	Superintending Surveyor	Survey of India, Dehradun	Representative of Survey of India
9.	Dr. G. D. Naidu	Scientist 'B'	CWPRS, Pune	Representative of CWPRS
10.	Sh. O.P. Gupta	Director, FE&SA	CWC, New Delhi	Member-Secretary NCSDP
II. Special Invitees and other officials				
11.	Dr. M.L. Sharma	Professor	DEQ, IIT Roorkee	IIT Roorkee
12.	Sh. S.K. Sibal	Chief Engineer UGBO, Lucknow	CWC	CWC
13.	Sh. Saibal Ghosh	Director, CMDD (N&W)	CWC	CWC
14.	Sh. Vivek Tripathi	Director, CMDD(E&NE)	CWC	CWC
15.	Dr Josodhir Das	Associate Professor	DEQ, IIT Roorkee	IIT Roorkee
16.	Sh. N. R. Bhattacharjee	Superintending Geologist	GSI, Kolkata	GSI
17.	Sh. Sachin N. Khupat	Scientist 'B'	CWPRS	CWPRS
18.	Sh. S. Selvam	Scientist 'B'	CWPRS	CWPRS
19.	Sh. Kuldeep Singh	Dy. Director	CWC	NCSDP Secretariat
20.	Sh. Satyam Aggarwal	Asst. Director	CWC	"
21.	Sh. C.L. Premi	Head Draftsman	CWC	"
22.	Sh. Man Singh	Head Draftsman	CWC	CWC

III. Project Representatives and Consultants				
23.	Sh. N.D. Arora	CESCPL	CESCPL, New Delhi	Phanchung HEP, Arunachal Pradesh
24.	Sh. Amit Sahay	-do-	-do-	-do-
24.	Sh. Rathna Kumar Vakkalagadda	-do-	-do-	-do-
25.	Sh. B.D. Barelia	Superintending Engineer	NVDA	Morand Dam Project, MP
26.	Sh. G.K. Khare	Sub Divisional Engineer	NVDA	-do-
27.	Dr I. D. Gupta	Advisor (Ex Director, CWPRS)	Advisor	-do-
28.	Sh. R. Krishnamurthy	Consultant	Secon Pvt Ltd.	-do-
29.	Dr. G. A. Mukhtar	Chief Geologist, JKSDPC	JKSDPC, Srinagar	New Ganderbal HEP. J&K
30.	Sh. Shakeel Ahmad	JKSDPC	JKSDPC	-do-
31.	Mrs. Meenakshi Raina	Liaison Officer	JKSDPC, New Delhi	-do-
32.	Sh. R.K. Gupta	Chief Engineer	CVPPL	Kwar HEP, J&K
33.	Sh. S.L. Kapil	General Manger	NHPC Ltd.	-do-
34.	Sh. Deepak Kumar	NHPC Ltd.	-do-	-do-
35.	Mrs. Pallavi Khanna	Dy. Manager	-do-	-do-
36.	Sh. Sandeep Sharma	Geologist	CVPP	-do-
37.	Sh. Ajay Singh	Manager (Geo)	NHPC Ltd.	-do-
38.	Sh. Ch. Siva Rama Prasad	Chief Engineer	WRD, Govt. of AP	Vamsadhara Project, Andhra Pradesh
39.	Sh. B. Seetha Ram	Deputy Executive Engineer	-do-	-do-
40.	Sh. M. Sivaram Kapil	Asst. Executive Engineer	-do-	-do-
41.	Sh. Vikas Chauhan	Sr. Manager	THDCL	Bunakha HEP, Bhutan
42.	Sh. P.K. Kulshreshtha	Sr. PS	-do-	-do-
43.	Sh. Vijay Kumar Sharma	Sr. D/Man	-do-	-do-
44.	Sh. Sanjeev Gupta	AGM	SJVNL	Luhri St-I, HEP, HP
45.	Sh. Mukesh Kumar Sharma	Sr. Manager	-do-	-do-
46.	Sh. Ashish Kaushal	Dy. Manager	-do-	-do-
47.	Sh. S. C. Baluni	General manager (C-NP0	UJVNL	Nand Prayag Langasu, Uttarakhand
48.	Sh. Harish Bahuguna	DGM (Geology)	-do-	-do-
49.	Sh. Shashank Kuimar Pandey	UJVNL	-do-	-do-
50.	Sh. Amitabh Tripathi	Chief Engineer (D&R)	WAPCOS Ltd.	Pancheshwar Multipurpose Project, India-Nepal
51.	Sh. O.P. Chhibber	CCE	-do-	-do-
52.	Sh. Amit Gawande	Sr. Engineer	-do-	-do-
53.	Sh. Mehakjeet Singh	Sr. Engineer	-do-	-do-
54.	Dr. G. A. Mukhtar	Chief Geologist, JKSDPC	JKSDPC, Srinagar	Kirthai-I HEP, J&K
55.	Sh. Shakeel Ahmad	JKSDPC	JKSDPC	-do-

56.	Mrs. Meenakshi Raina	JKSDPC	JKSDPC, New Delhi	Kirthai-I HEP. J&K
57.	Sh. Vikas Chauhan	Sr. Manager	THDCL	Sankosh HEP, Bhutan
58.	Sh. P.K. Kulshreshtha	Sr. PS	-do-	-do-
59.	Sh. Vijay Kumar Sharma	Sr D/Man	-do-	-do-
60.	Sh. B.D. Barelia	Superintending Engineer	NVDA	Ganjal Dam Project, MP
61.	Sh. G.K. Khare	Sub Divisional Engineer	NVDA	-do-
62.	Dr. I. D. Gupta	Advisor (Ex Director, CWPRS)	Advisor	-do-
63.	Sh. R. Krishnamurthy	Consultant	Secon Pvt. Ltd.	-do-

Annexure-II

Minutes of the group meeting held on 31st May, 2016 as a follow up of decision taken in the 30th meeting of NCSDP held on 15th September, 2015

The group meeting was held on 31st May 2016 as a follow of decision taken in the 30th meeting of NCSDP held on 15th September, 2015, at Central Water Commission, New Delhi under the chairmanship of Dr B. R. K. Pillai, Chief Engineer (DSO), CWC. The list of Members who attended the meeting is given at ***Annexure I***.

1. Dr. L. R. Pattanur, CWPRS informed the group that their main concern is the earthquake magnitude to be assigned to the Main Boundary Thrust (MBT). Subsequently, Dr G. D. Naidu, CWPRS made a presentation on the issue. The issue raised by CWPRS was discussed in detail and following was decided:

"The potential of decollement be considered as magnitude 8.0 with appropriate distance for whole Himalayas unless reasons are given for lower potential. However, splays MBT/MCT may be assigned potential as per the practice of DSHA."

2. Dr Pillai requested representative of IIT Roorkee to update about the status of the Region Specific Seismic Study (South Indian Region) undertaken by IIT Roorkee with funding from DRIP. In response, Dr. M L Sharma, IITR informed the group that the aforesaid studies have been initiated and they are utilizing the IMD data for the study. Dr Sharma also mentioned that they need the locations of DRIP dams for the study. Dr Pillai said that the study is for the whole identified region and not for the DRIP dam alone. However, he agreed that the requisite information will be made available to IIT Roorkee by the DSR Directorate, CWC.

3. The issue of Seismic Instruments at DRIP dams location was also discussed. Dr. Pilllai explained the objective of DRIP works and informed the scope of Instrumentation in all the DRIP dams. He also pointed out major challenge with collecting and analysing the data; and ensuring fool proof working of such instruments. So, he invited collaborations from Agencies i.e. IIT Roorkee, NGRI and CWPRS, for seismic data collection, analysing and long term archiving, which was readily agreed.

After brief discussion, members came to an agreement along following lines:

1. (i) The DRIP dams falling in Tamilnadu, Kerala and Karnataka will be covered by NGRI
   (ii) The DRIP dams falling in Odisha and Jharkhand will be covered by CWPRS
   (iii) The DRIP dams falling in Madhya Pradesh and Uttarakhand will be covered by IIT Roorkee

2. The specification of the seismic instruments to be provided will be given by respective agencies. In addition, some of the dams can also be considered for specialised instruments to benefit R&D activities. The instruments will be procured and installed by the respective dam owners utilizing DRIP funds.

3. The data will be transmitted through GPRs to the respective agencies. For any seismic event with respect to any of the dam, a report will be generated by the respective agency and transmitted to the concerned dam owner. The agencies will be free to utilize the long term data of respective dam for research and development activities.

4. No cost will be paid to the agencies for above collaborative efforts. The malfunctioning of any seismic instrument will be notified by the respective agency to the concerned dam owner and rectification of the same will be carried out by dam owner at their own cost.

5. Draft MOU will be prepared by NGRI and the same will be shared by CWC with other agencies before processing of the same.

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Annexure-I

Group Meeting held on 31st May, 2016 as a follow up of decision taken in 30th meeting of NCSDP held on 15th September, 2015

List of Participants present

Sl. No.	Name & Address	Designation	Deptt./ Org.
1.	Dr. B.R.K. Pillai	Chief Engineer (DSO)	CWC, New Delhi
2.	Dr. D. Srinagesh	Chief Scientist, CSIR	NGRI, Hyderabad
3.	Dr. Yogendra Singh	Professor & Head Deptt. of Earthquake Engg.	DEQ, IIT Roorkee,
4.	Dr. M.L. Sharma	Professor, Deptt. of Earthquake Engg.	DEQ, IIT Roorkee,
5.	Dr. Manish Shikhande	Professor, Deptt. of Earthquake Engg.	DEQ, IIT Roorkee,
6.	Dr. P R Baidya	Scientist 'E' (EMS)	National Seismological Centre, IMD, New Delhi
7	Dr. L.R. Pattanur	Scientist 'D'	CWPRS, Pune
8.	Dr. Jasodhir Das	Associate Professor, Deptt. of Earthquake Engg.	DEQ, IIT Roorkee,
9	Dr. G. D. Naidu	Scientist 'B'	CWPRS
10	Sh. O.P. Gupta	Director, FE&SA, CWC & Member Secretary, NCSDP	CWC, New Delhi

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Annexure-III

Government of India
भारत सरकार
Ministry of Water Resources,
River Development & Ganga Rejuvenation
जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय
Central Water and Power Research Station
केन्द्रीय जल और विद्युत अनुसंधान शाला
Khadakwasla, Pune 411 024
खड़कवासला, पुणे - 411 024

Phone : 020-24103421, 24103356
Fax : 020-24381004
e-mail : lrpattanur@yahoo.co.in
Web Site: www.cwprs.gov.in
www.mowr.gov.in

No. 324/41/2015-ES/ Date : 5.7.2016

To

Shri. O.P. Gupta
Director, FE&SA Dte, CWC &
Member Secretary NCSDP
Sewa Bhawan, R.K. Puram
New Delhi – 110 066

Sub. : Revised reports of the studies of 'Estimation Of Site-specific Seismic Design Parameters for Pancheshwar Multipurpose Project (Concrete Dam), Nepal / India and Nand Prayag Langasu HEP, Uttarakhand

Sir,

The studies of 'Estimation of Site-specific Seismic Design Parameters for Pancheswar Multipurpose Project (Concrete Dam), Nepal / India' and Nand Prayag Langasu HEP, Uttarakhand are duly revised and the soft copy of the same are send through e-mail as attachments.

Thanking you.

Yours faithfully,

(L.R. Pattanur)
Scientist 'D'

Annexure-IV

भूकम्प अभियांत्रिकी विभाग
भारतीय प्रौद्योगिकी संस्थान रुड़की
रुड़की – 247 667, उत्तराखण्ड, भारत
DEPARTMENT OF EARTHQUAKE ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247 667, UTTARAKHAND, INDIA
Telephone : +91 - 1332 - 285228, 285534(O), 285042 (R)
Fax : +91 - 1332 - 276899 / 273560
E-mail : quake@iitr.ac.in; yogenfeq@iitr.ac.in
Web. : www.iitr.ac.in

डॉ० योगेन्द्र सिंह
प्राध्यापक एवं विभागाध्यक्ष
Dr. Yogendra Singh
Professor & Head

No. EQD/
Dated: Sept. 12, 2016

Shri. O.P. Gupta
Director (FE&SA) & Member Secy (NCSDP)
Govt. of India
Central Water Commission
FE&SA Directorate
712(A), Sewa Bhawan, R.K. Puram,
NEW DELHI- 110 066

Dear Shri Gupta,

This is in reference to the 31st Meeting of the NCSDP held on June 23, 2016.

The work on modifications of the various parameters suggested by the Committee Members is now incorporated in the respective reports. The site specific parameters namely, PGA for horizontal and vertical conditions and the seismic coefficient alongwith the spectra for the various conditions are included. Other information regarding micro earthquake studies of Kwar Project and the matter related to Puncheshwar Dam has already been sent. The report numbers of the respective Dam site carried out by IIT Roorkee have to be modified by adding (M).

This is for your kind information and further necessary action.

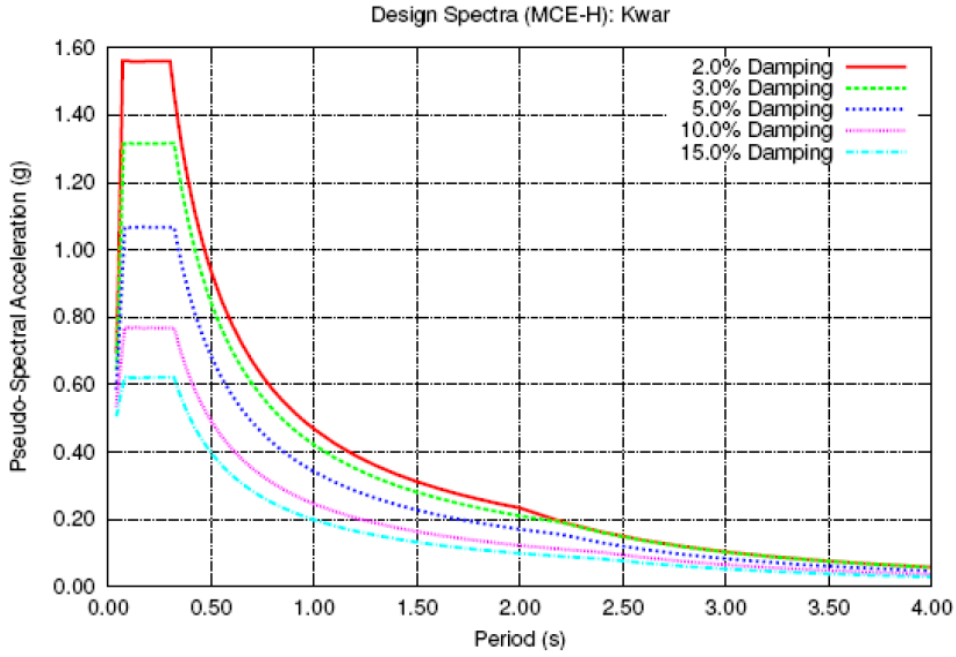
With regards,

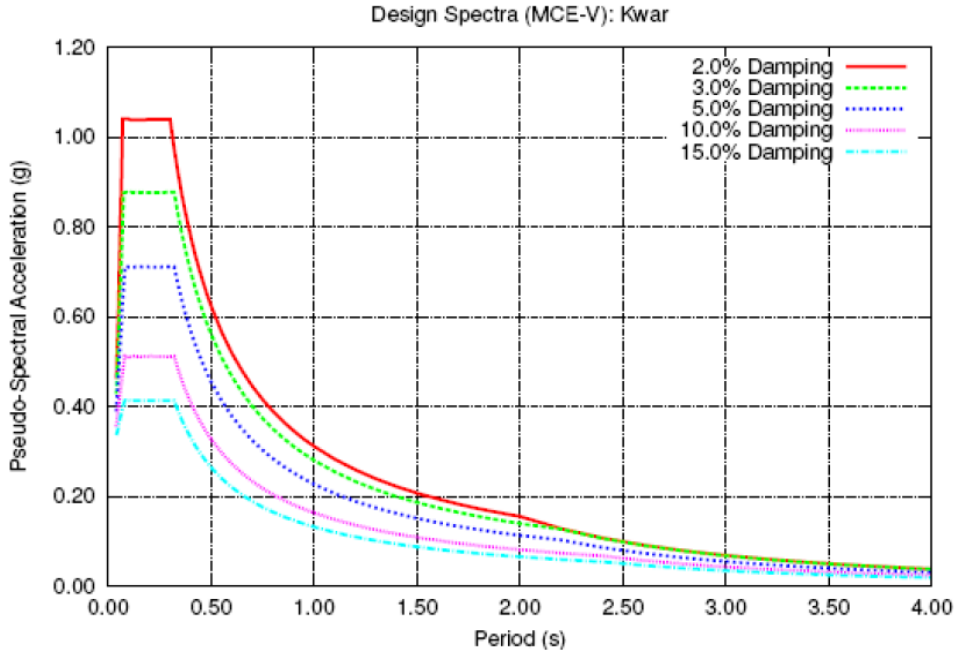
Yours sincerely,

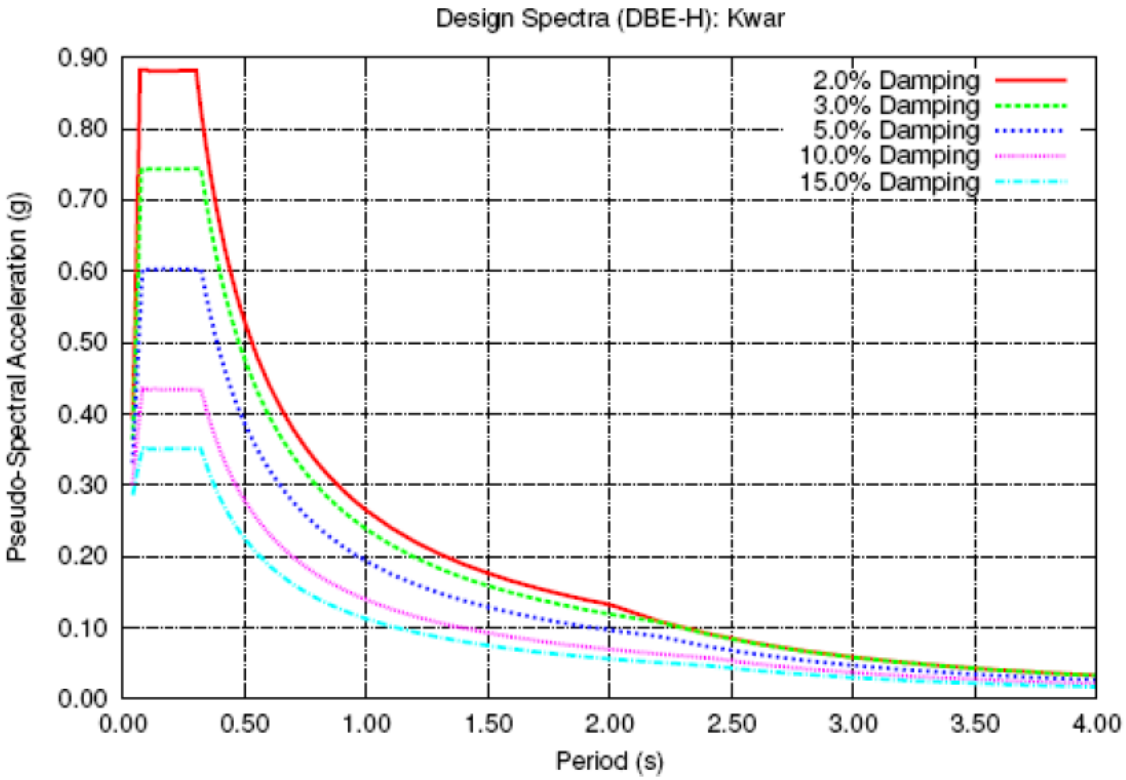
(Yogendra Singh)
Prof. & Head

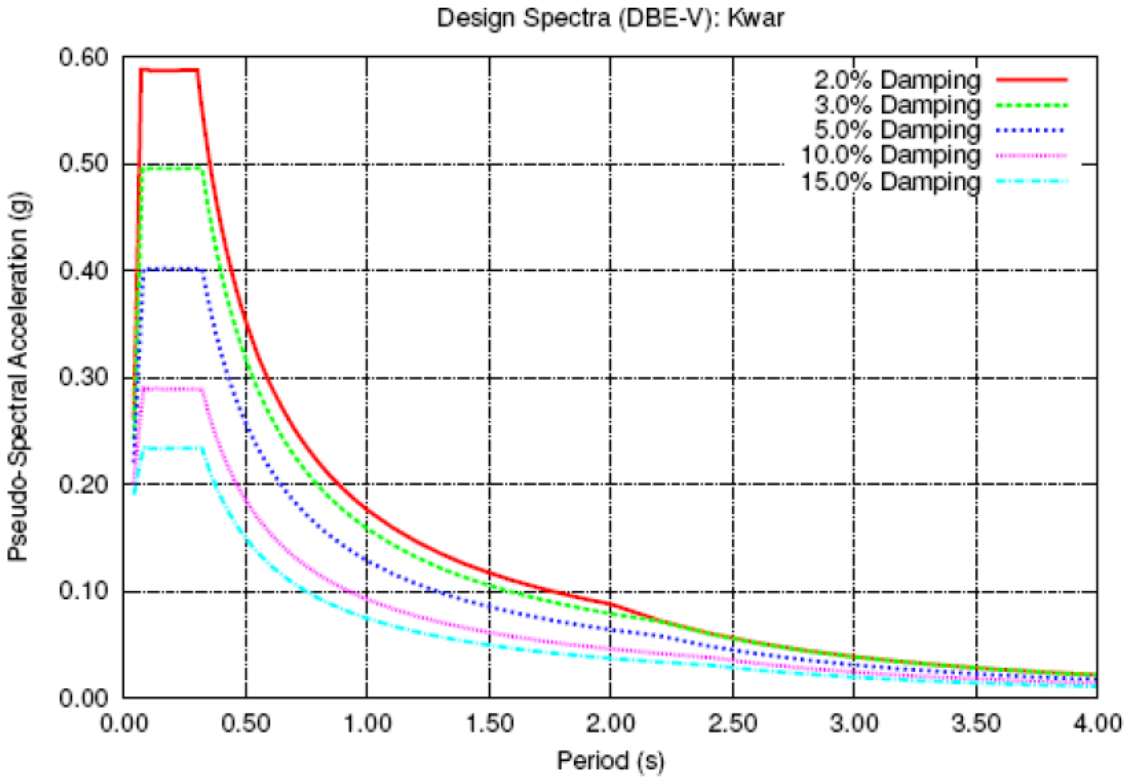
KWAR

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.50g	0.28g	0.33g	0.19g	0.16	0.11





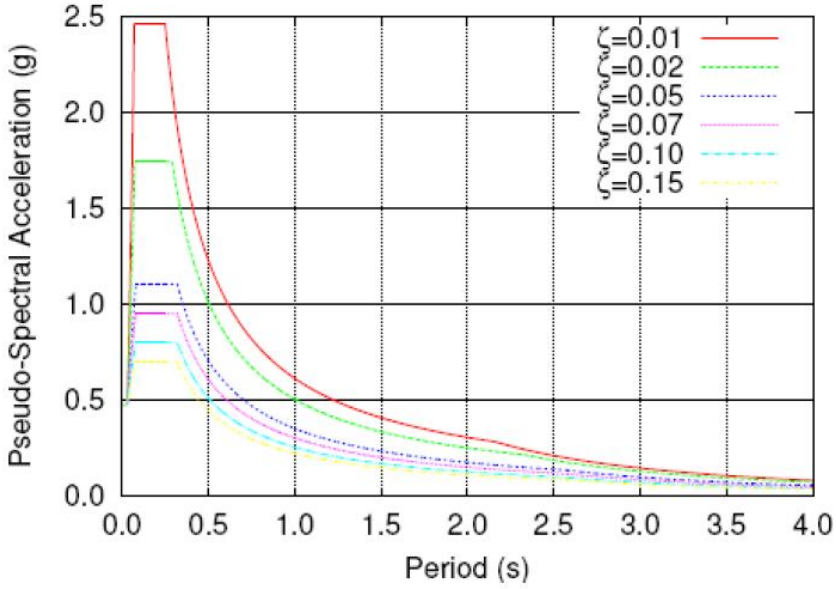

Design Spectra (DBE-H): Kwar
Pseudo-Spectral Acceleration (g)
Period (s)
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00


Design Spectra (DBE-V): Kwar
Pseudo-Spectral Acceleration (g)
Period (s)
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

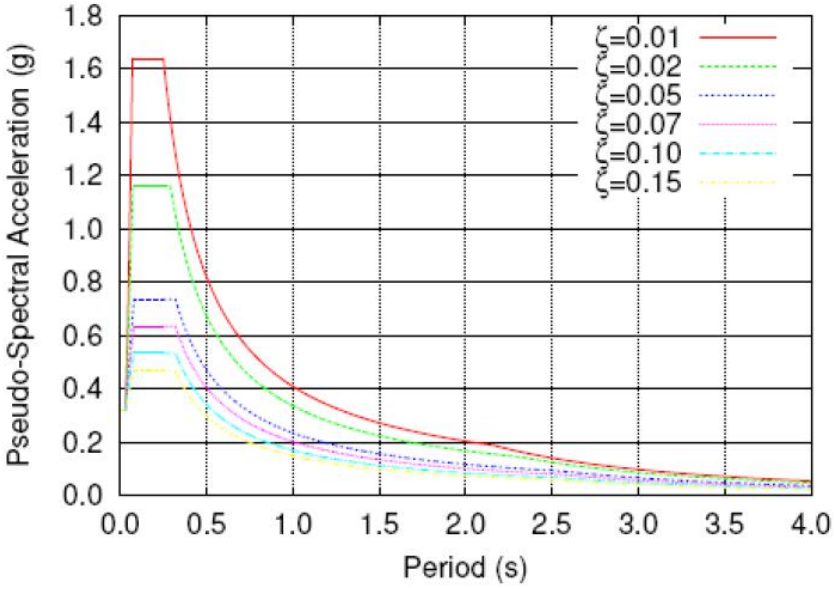
KIRTHAI-I

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.48g	0.30g	0.32g	0.20g	0.18	0.12

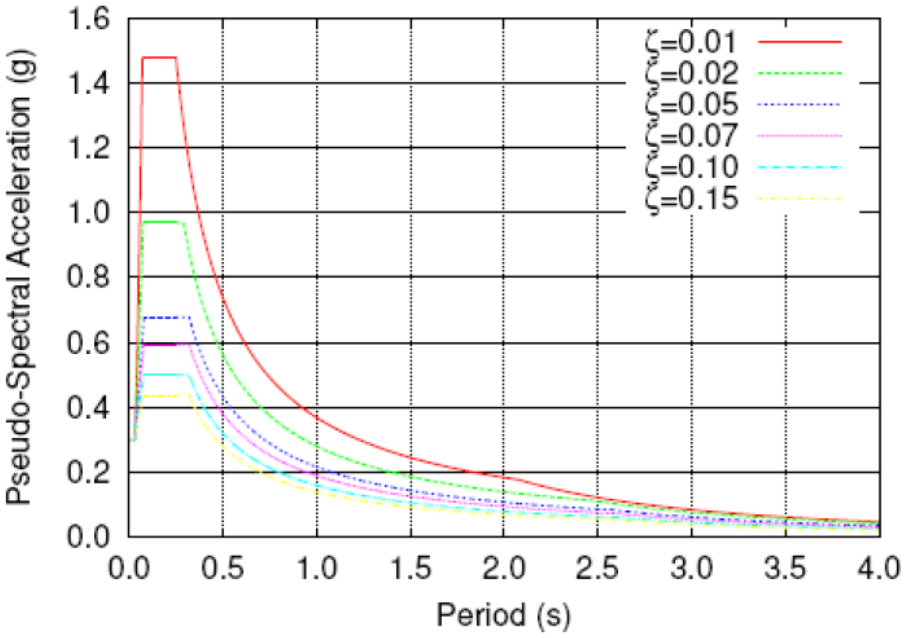
MCE(H)



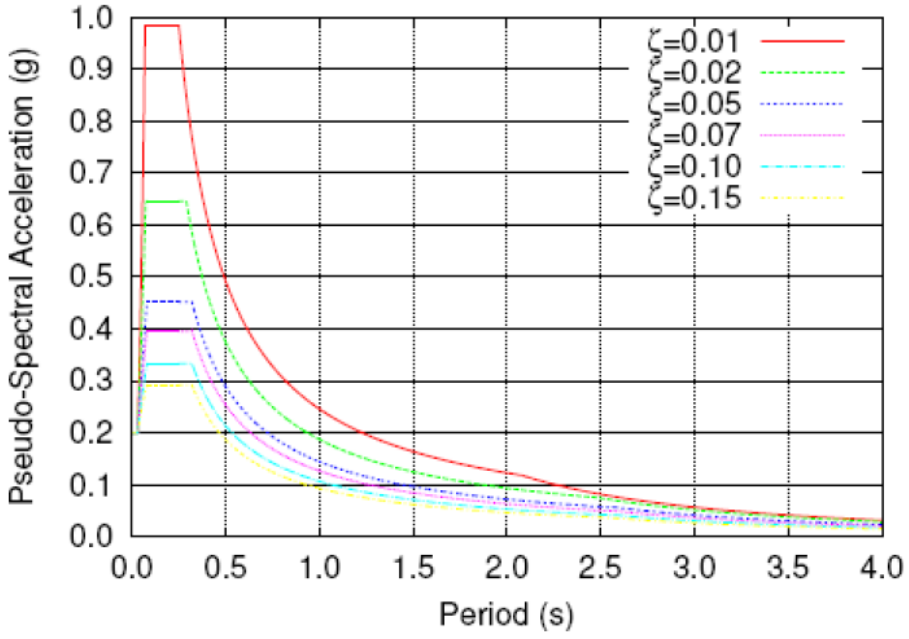
MCE(V)



DBE(H)


Pseudo-Spectral Acceleration (g)
Period (s)
ζ=0.01
ζ=0.02
ζ=0.05
ζ=0.07
ζ=0.10
ζ=0.15
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

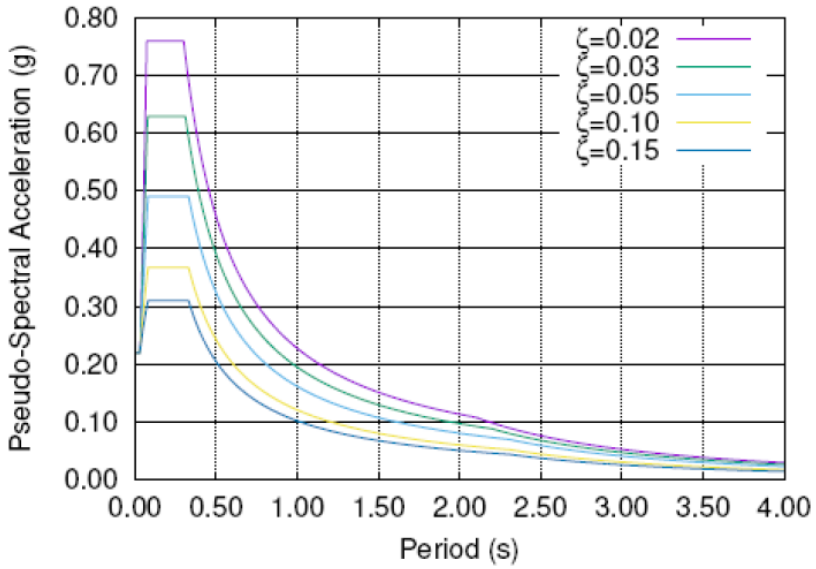
DBE(V)


Pseudo-Spectral Acceleration (g)
Period (s)
ζ=0.01
ζ=0.02
ζ=0.05
ζ=0.07
ζ=0.10
ζ=0.15
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

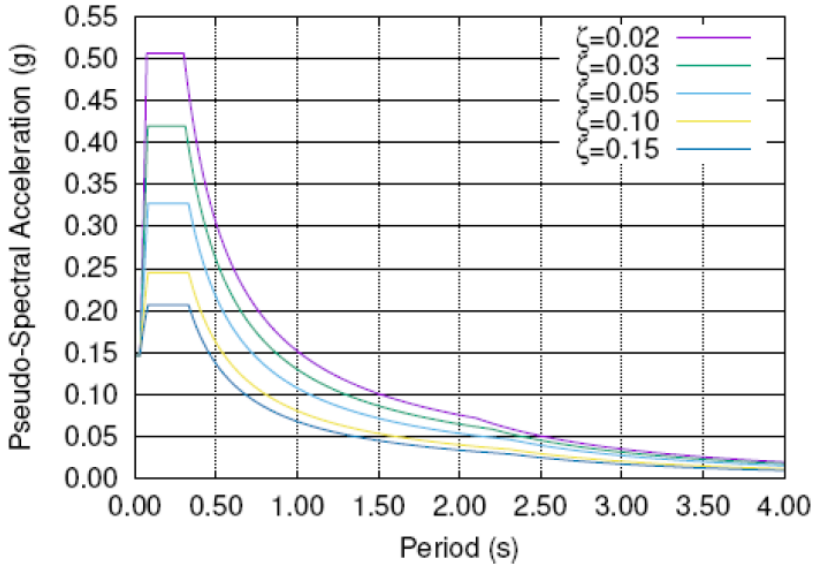
HIRAMANDLAM

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
6.0	0	15	0.22g	0.09g	0.15g	0.06g	0.06	0.04

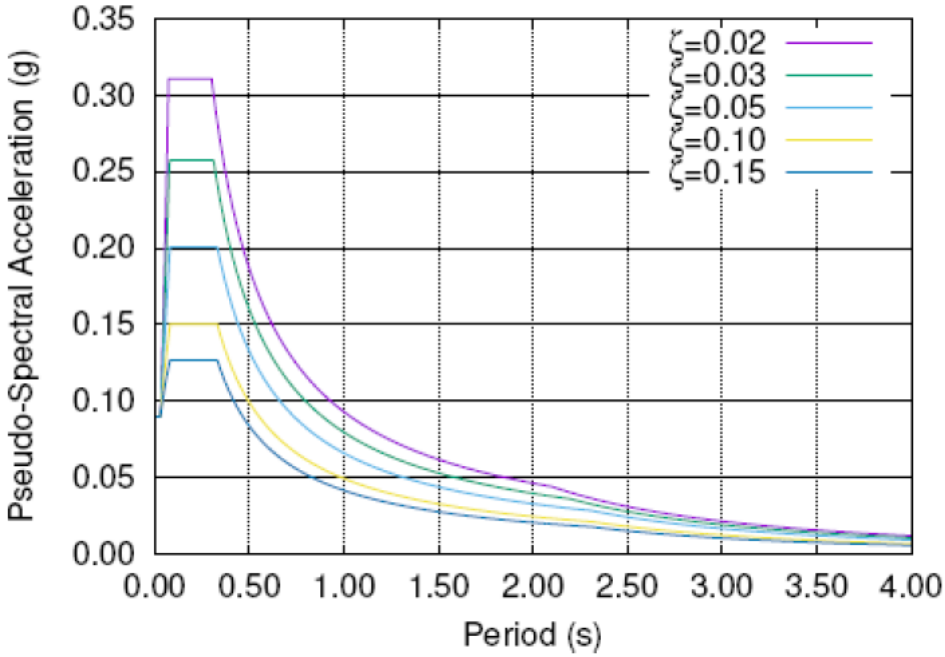
MCE(H)



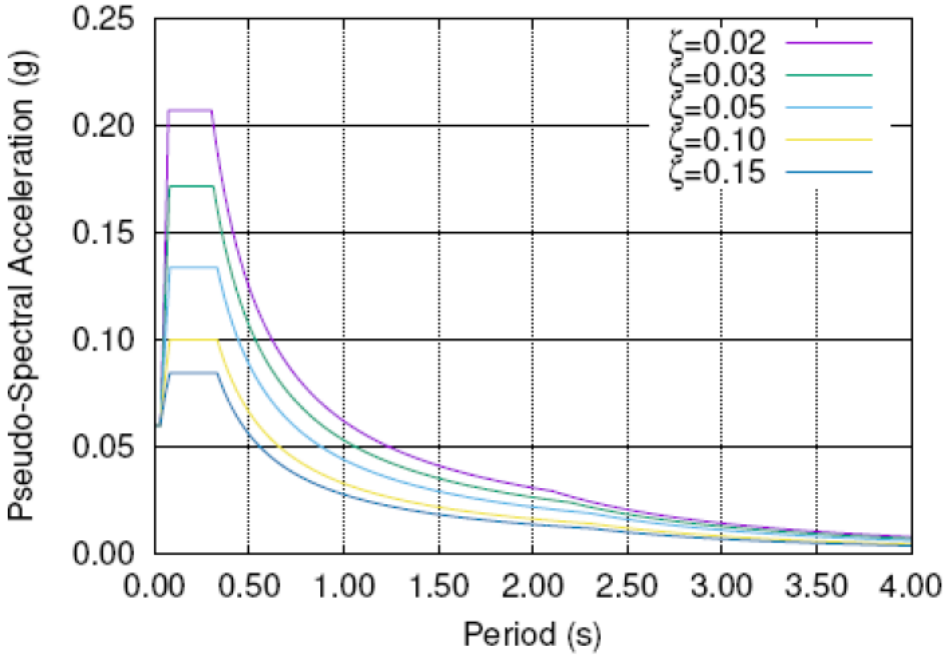
MCE(V)



DBE(H)


Pseudo-Spectral Acceleration (g)
Period (s)
ζ=0.02
ζ=0.03
ζ=0.05
ζ=0.10
ζ=0.15
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

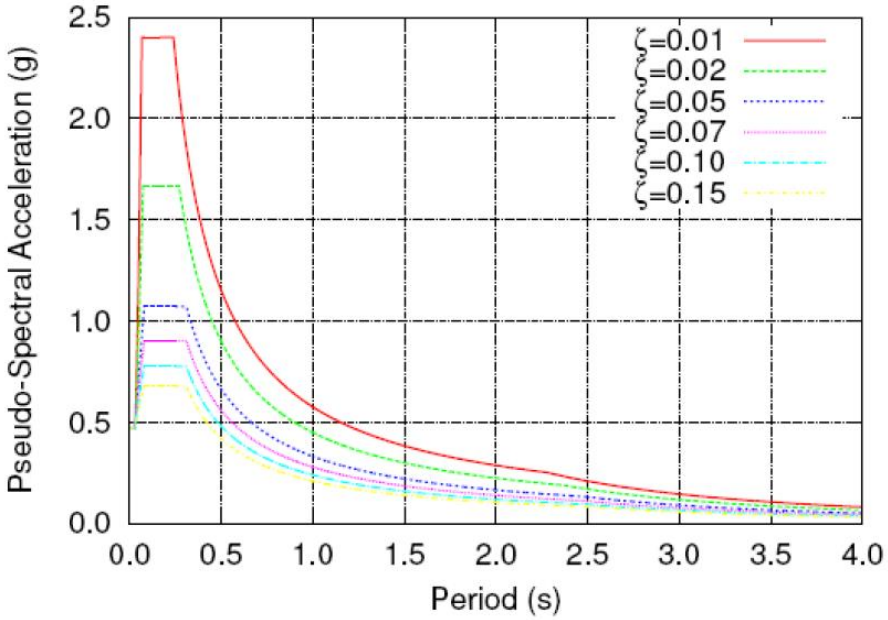
DBE(V)


Pseudo-Spectral Acceleration (g)
Period (s)
ζ=0.02
ζ=0.03
ζ=0.05
ζ=0.10
ζ=0.15
0.00
0.05
0.10
0.15
0.20
0.25
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

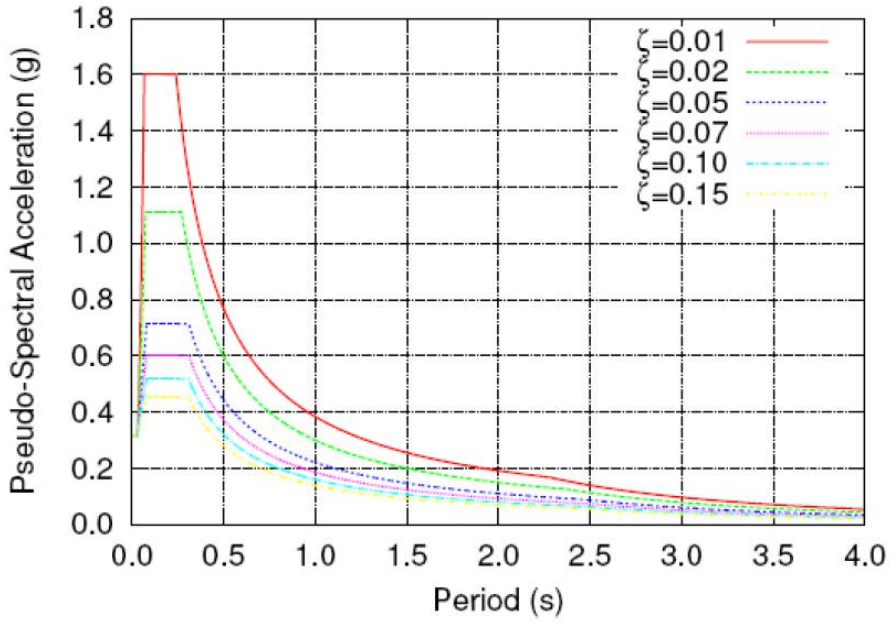
LUHRI-Stage-I

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.50g	0.28g	0.33g	0.19g	0.24	0.16

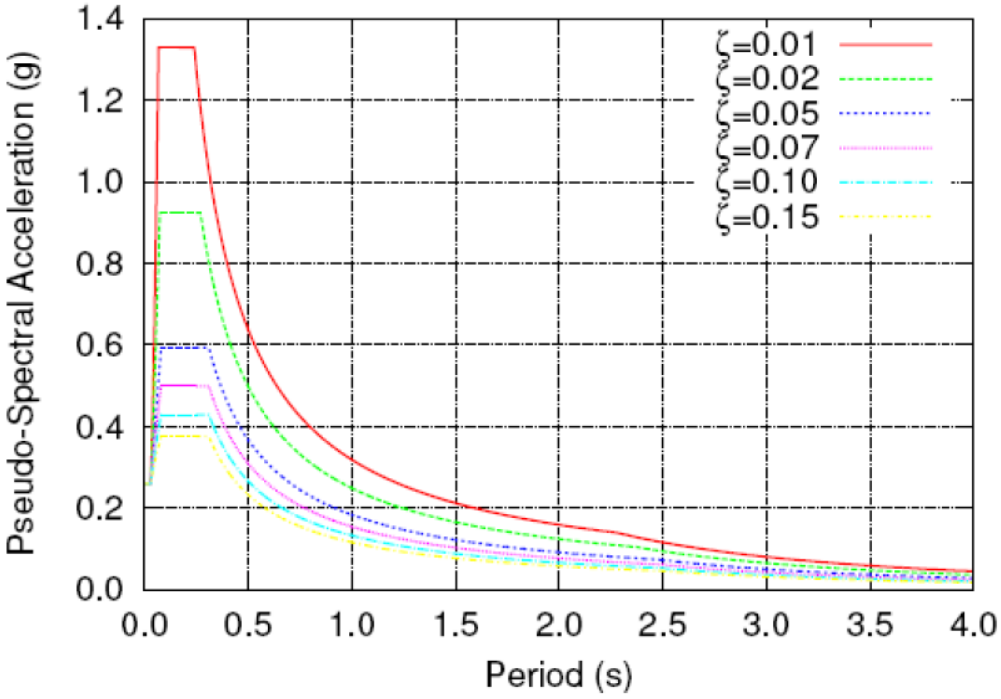
MCE(H)



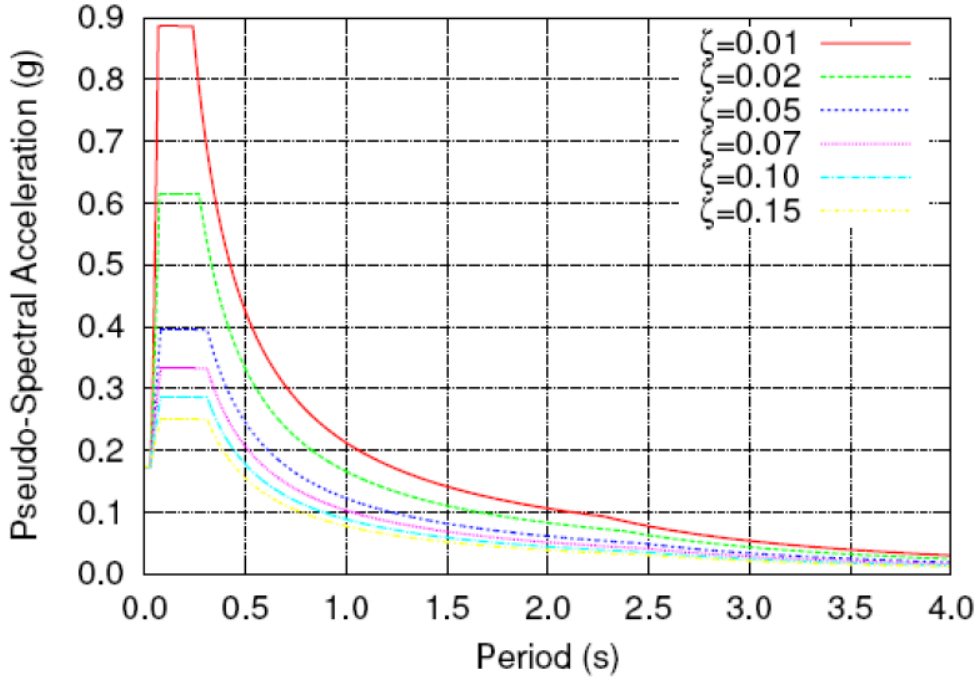
MCE(V)



DBE(H)

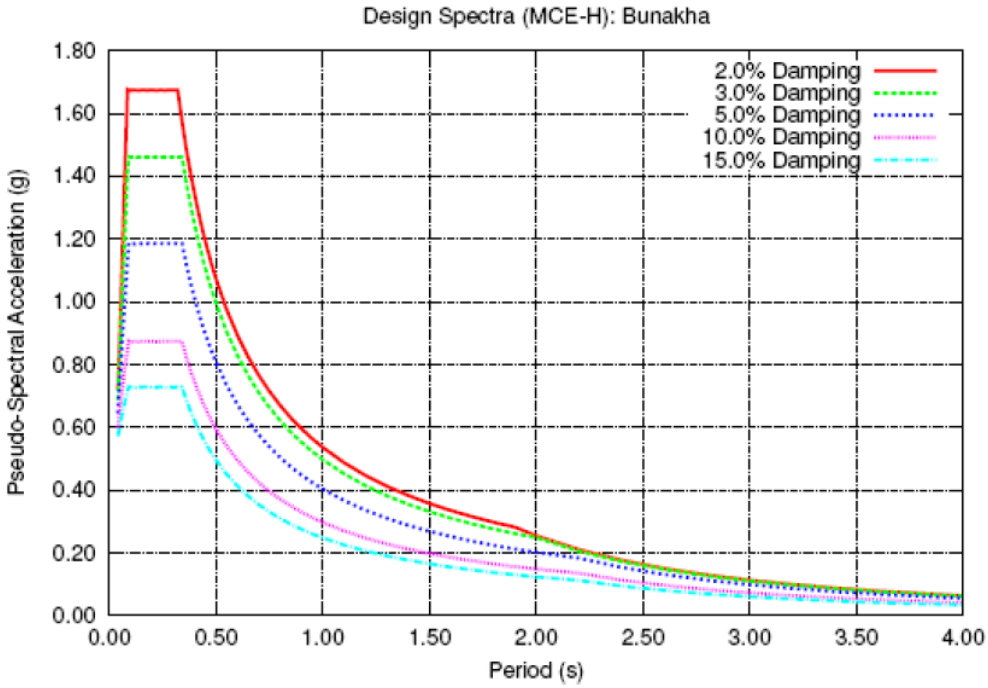

Pseudo-Spectral Acceleration (g)
Period (s)
ζ=0.01
ζ=0.02
ζ=0.05
ζ=0.07
ζ=0.10
ζ=0.15
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

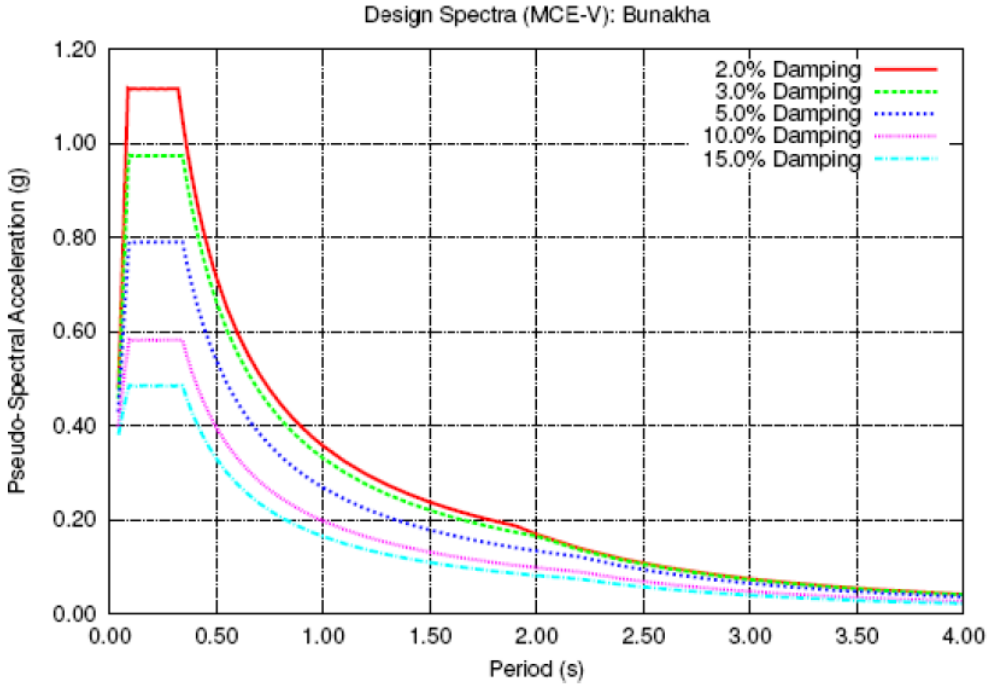
DBE(V)

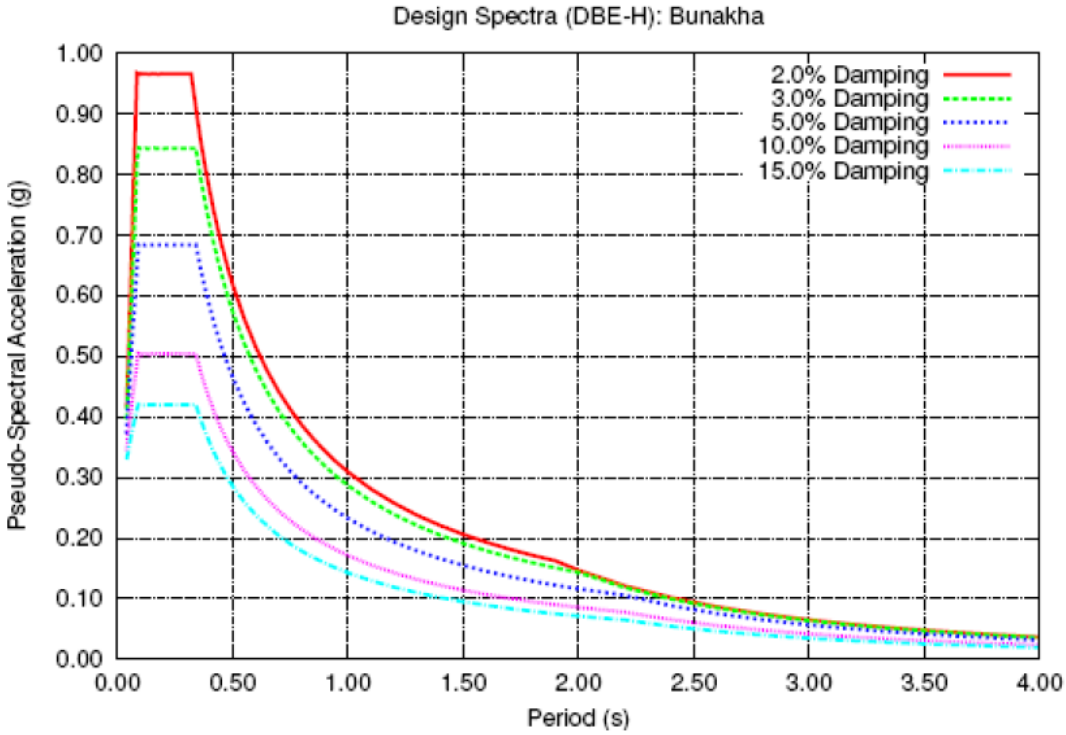

Pseudo-Spectral Acceleration (g)
Period (s)
ζ=0.01
ζ=0.02
ζ=0.05
ζ=0.07
ζ=0.10
ζ=0.15
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

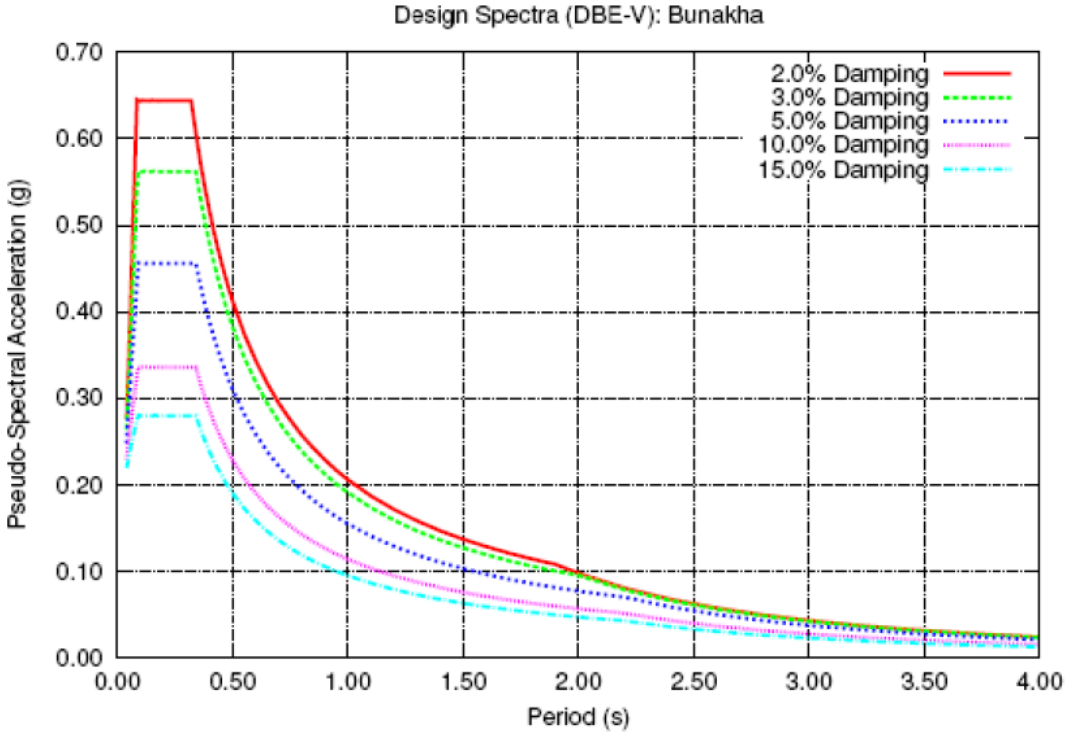
BUNAKHA

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.52g	0.30g	0.35g	0.20g	0.24	0.16



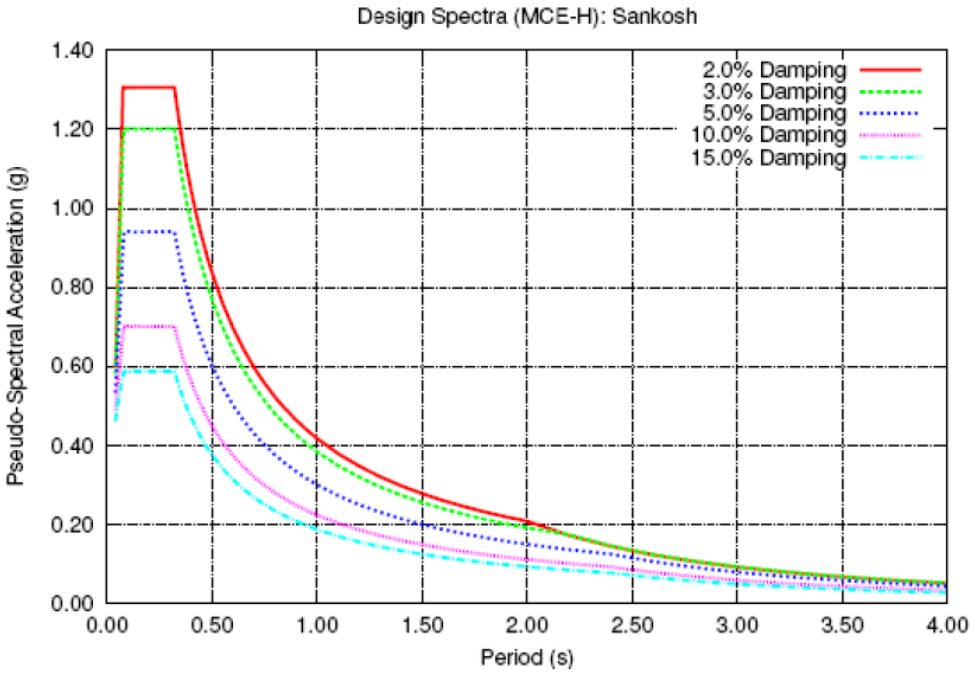


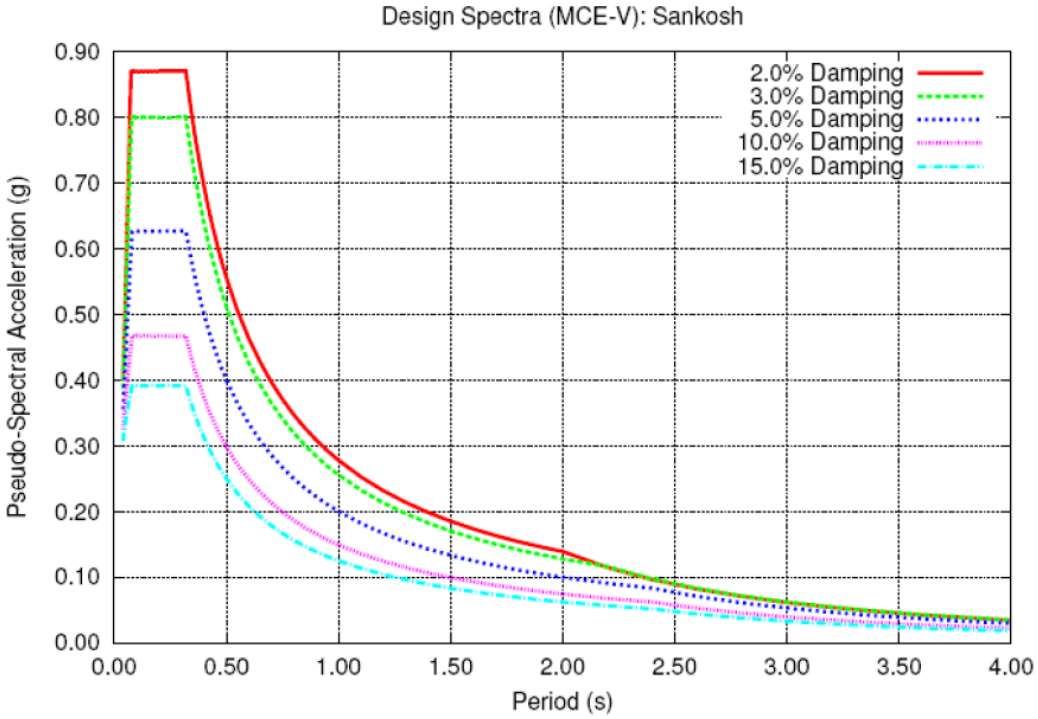

Design Spectra (DBE-H): Bunakha
Pseudo-Spectral Acceleration (g)
Period (s)
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

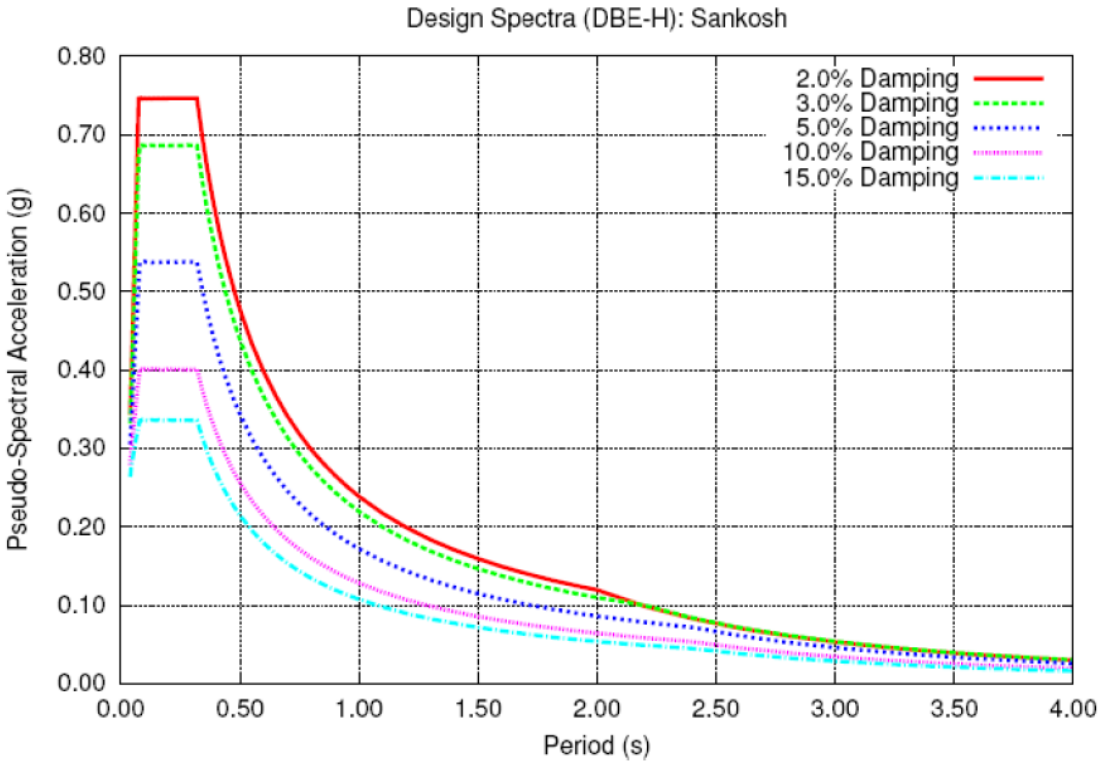

Design Spectra (DBE-V): Bunakha
Pseudo-Spectral Acceleration (g)
Period (s)
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

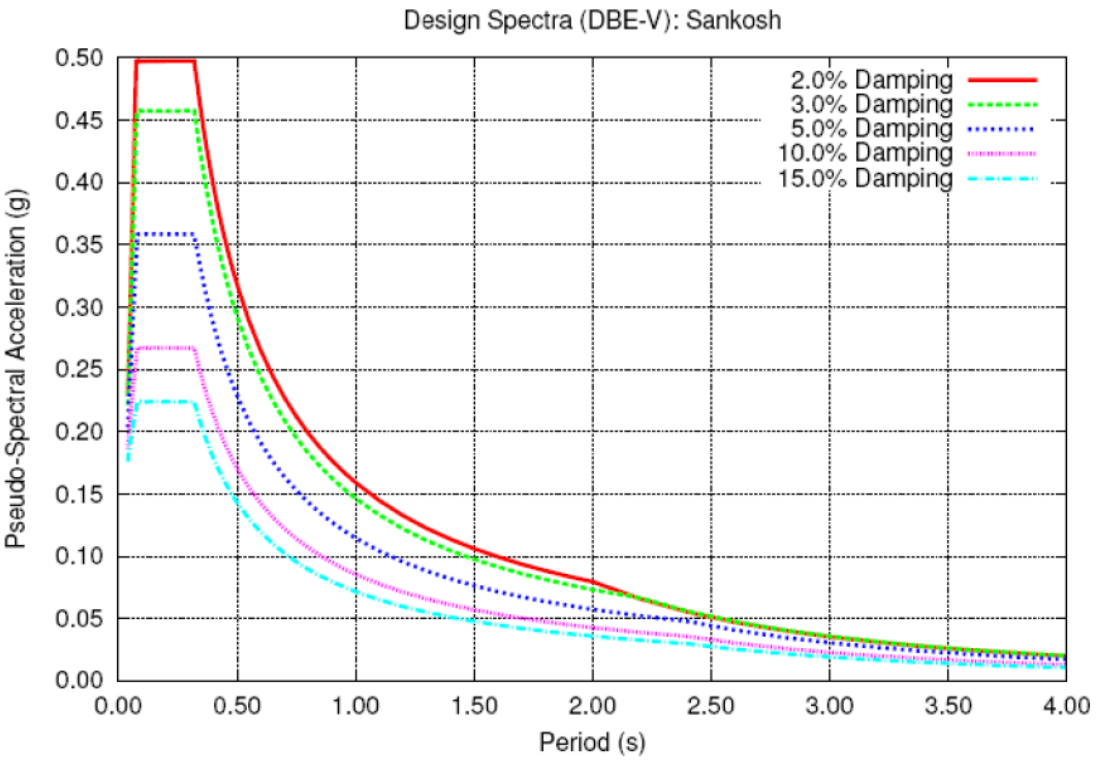
SANKOSH

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.46g	0.26g	0.31g	0.17g	0.24	0.16



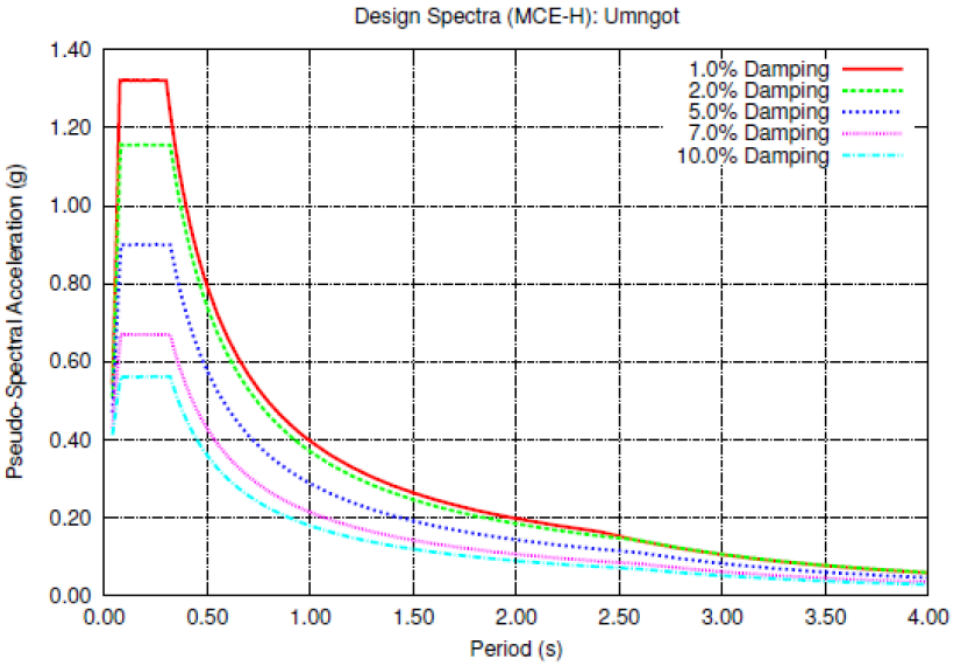


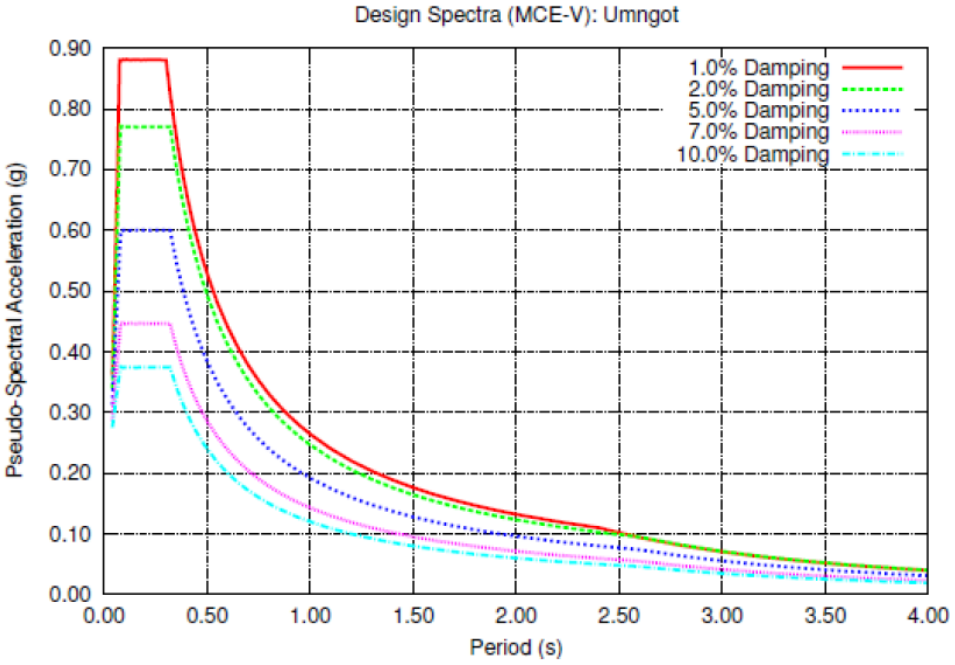

Design Spectra (DBE-H): Sankosh
Pseudo-Spectral Acceleration (g)
Period (s)
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

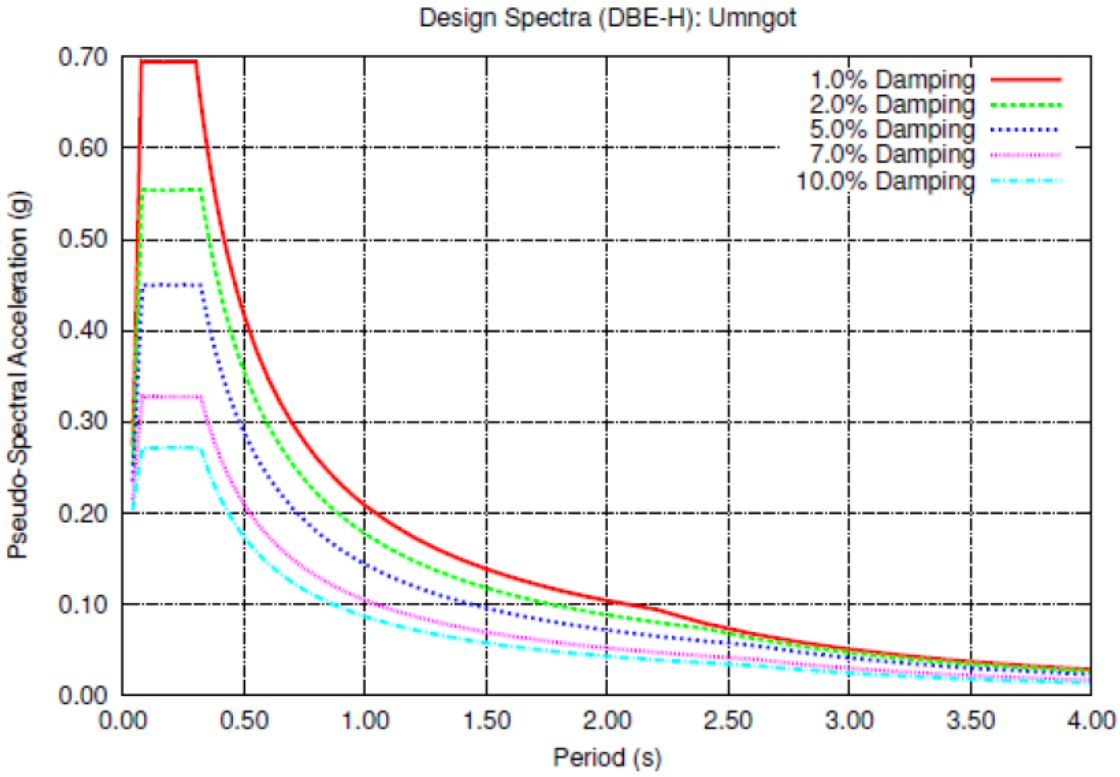

Design Spectra (DBE-V): Sankosh
Pseudo-Spectral Acceleration (g)
Period (s)
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

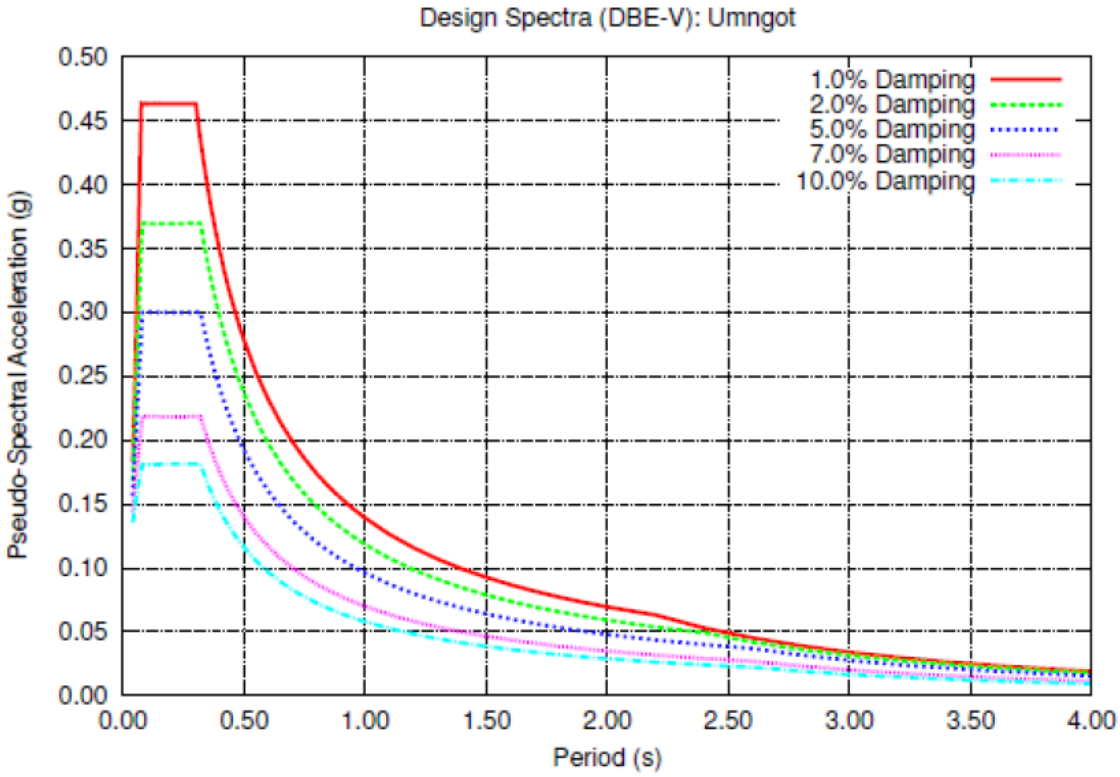
UMNGOT

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	22	15	0.36g	0.18g	0.24g	0.12g	0.24	0.16



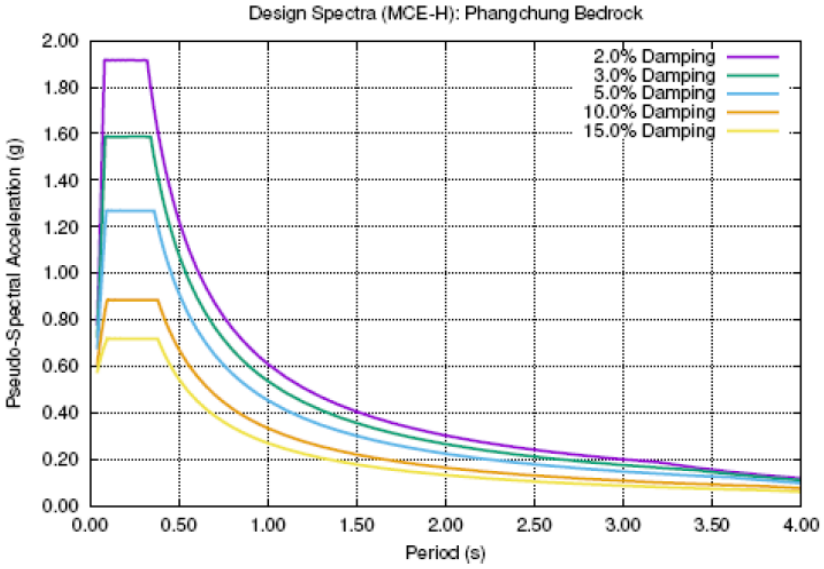


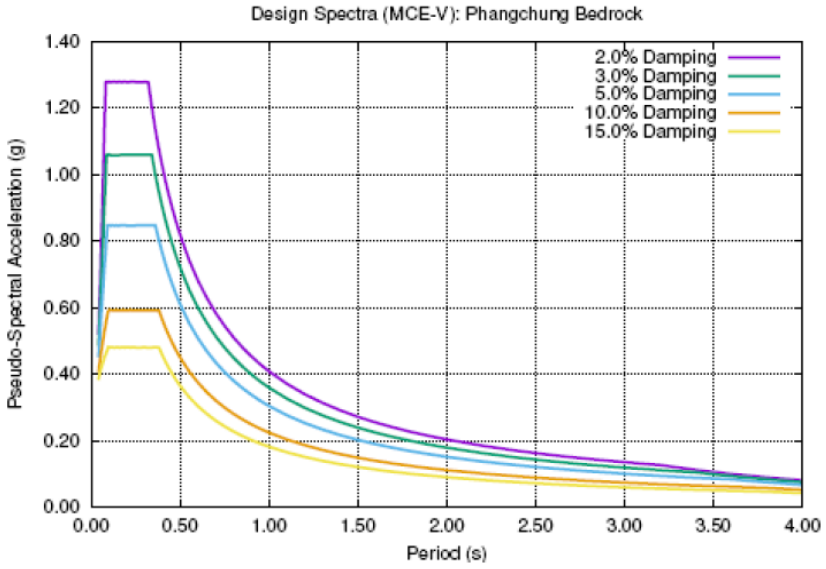

Design Spectra (DBE-H): Umngot
Pseudo-Spectral Acceleration (g)
Period (s)
1.0% Damping
2.0% Damping
5.0% Damping
7.0% Damping
10.0% Damping
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

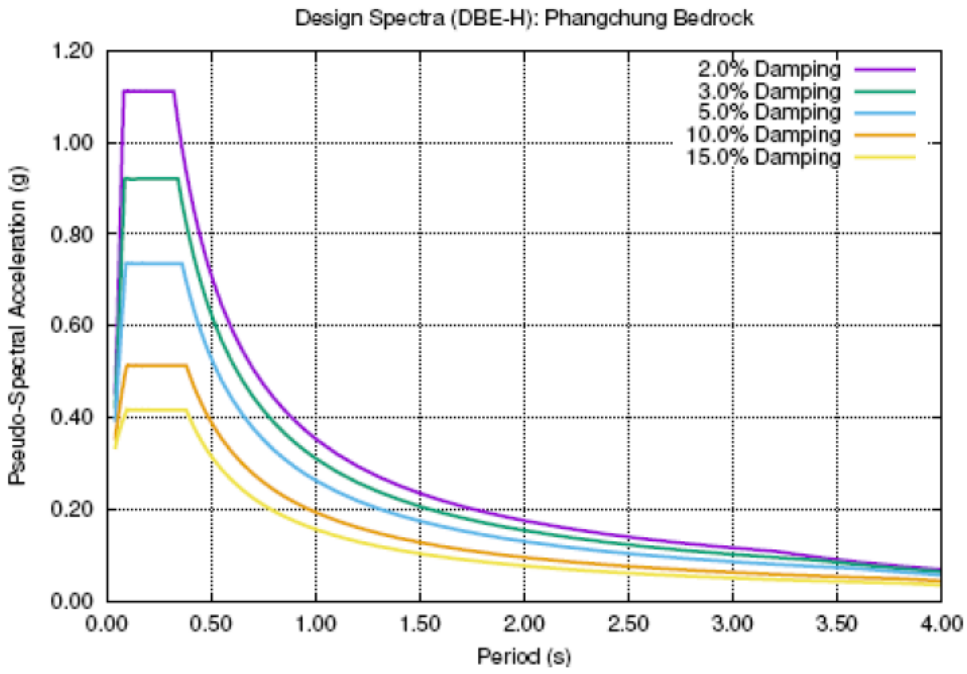

Design Spectra (DBE-V): Umngot
Pseudo-Spectral Acceleration (g)
Period (s)
1.0% Damping
2.0% Damping
5.0% Damping
7.0% Damping
10.0% Damping
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

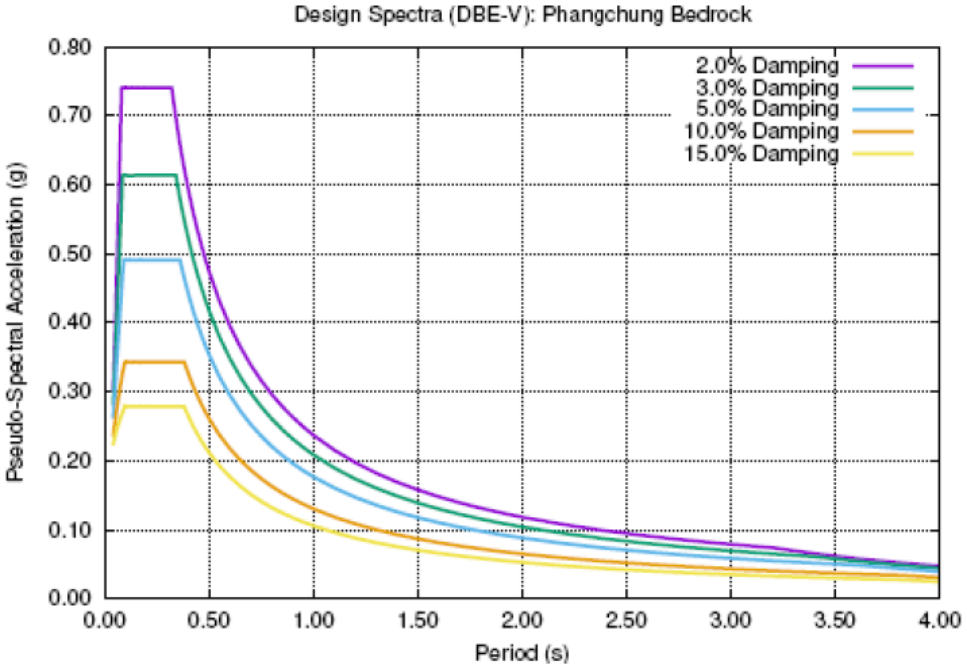
PHANGCHUNG
(BEDROCK)

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.538	0.312	0.36	0.21	0.24	0.16



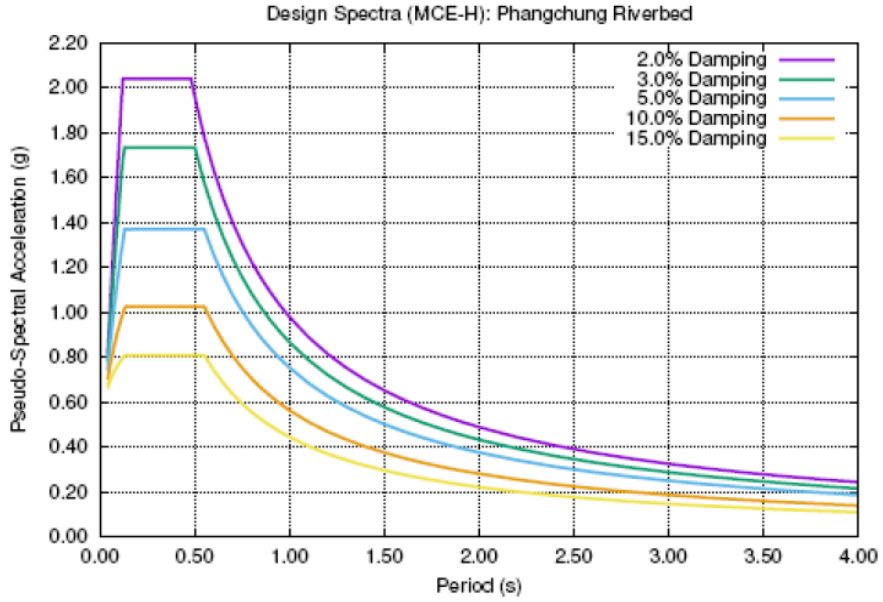


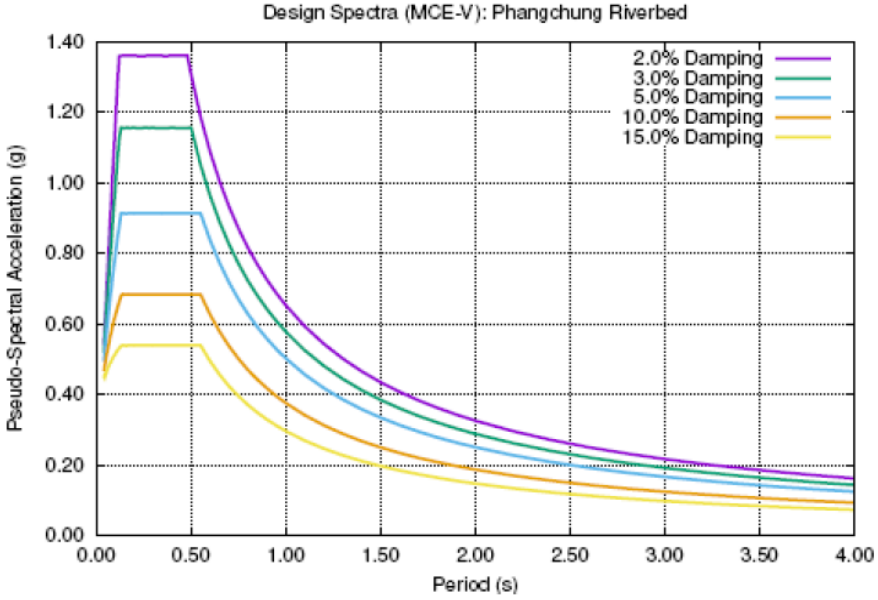

Design Spectra (DBE-H): Phangchung Bedrock
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
Pseudo-Spectral Acceleration (g)
Period (s)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

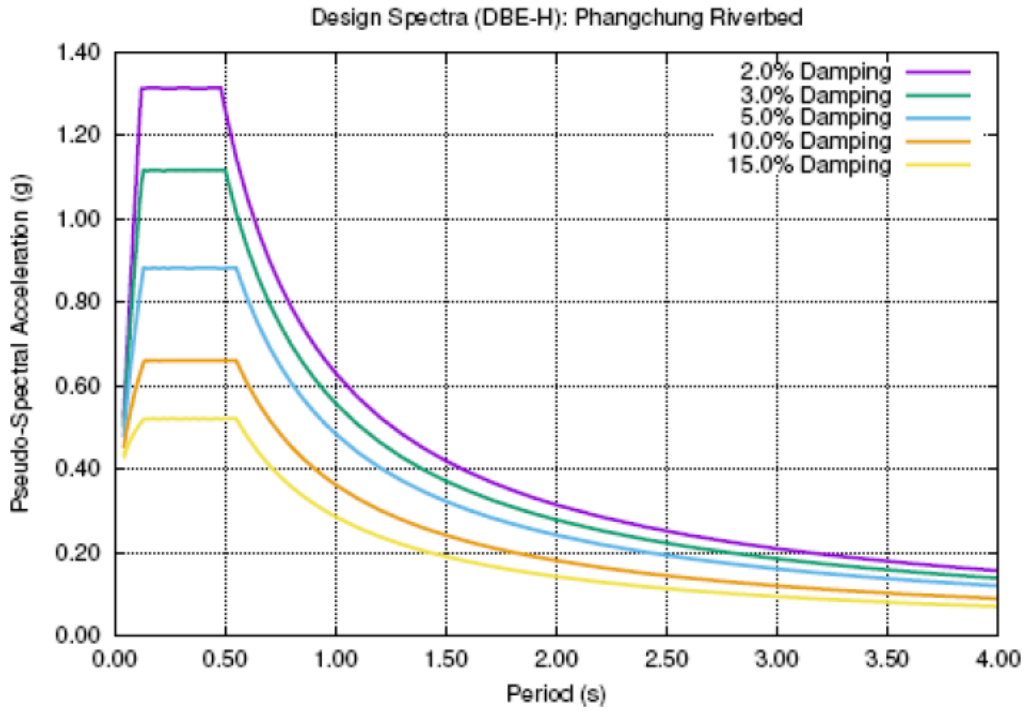

Design Spectra (DBE-V): Phangchung Bedrock
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
Pseudo-Spectral Acceleration (g)
Period (s)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

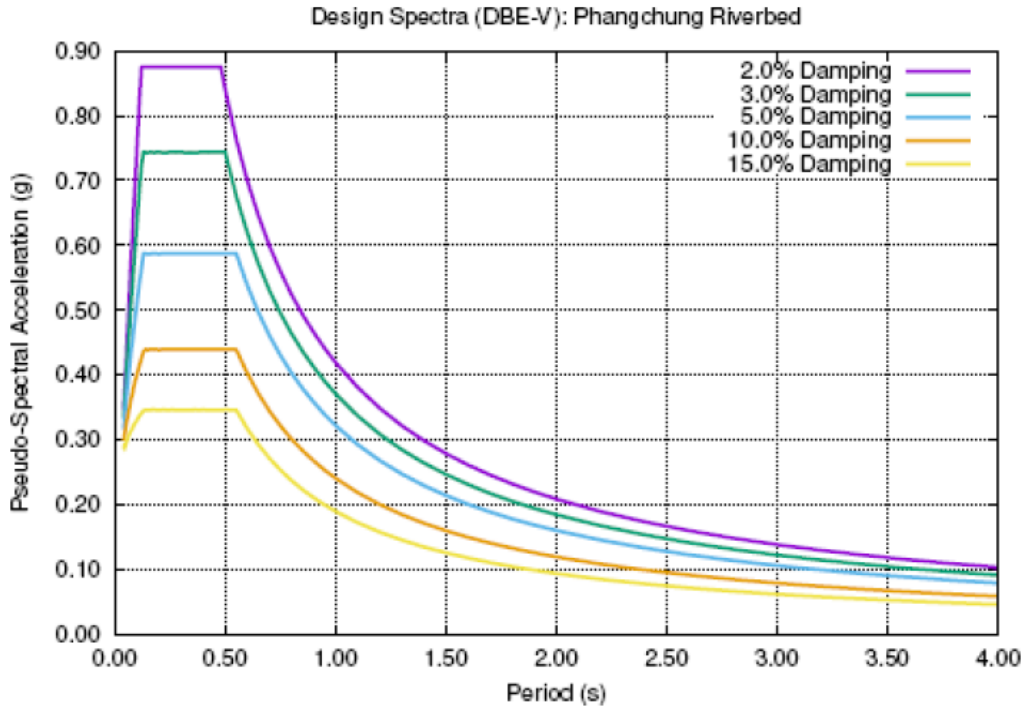
PHANGCHUNG (RIVERBED)

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.637	0.41	0.43	0.27	0.24	0.16





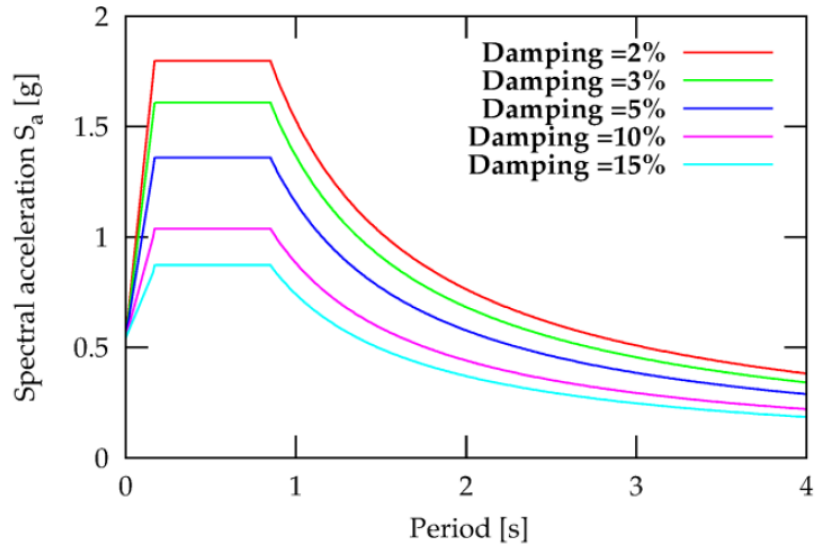

Design Spectra (DBE-H): Phangchung Riverbed
Pseudo-Spectral Acceleration (g)
Period (s)
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00


Design Spectra (DBE-V): Phangchung Riverbed
Pseudo-Spectral Acceleration (g)
Period (s)
2.0% Damping
3.0% Damping
5.0% Damping
10.0% Damping
15.0% Damping
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00

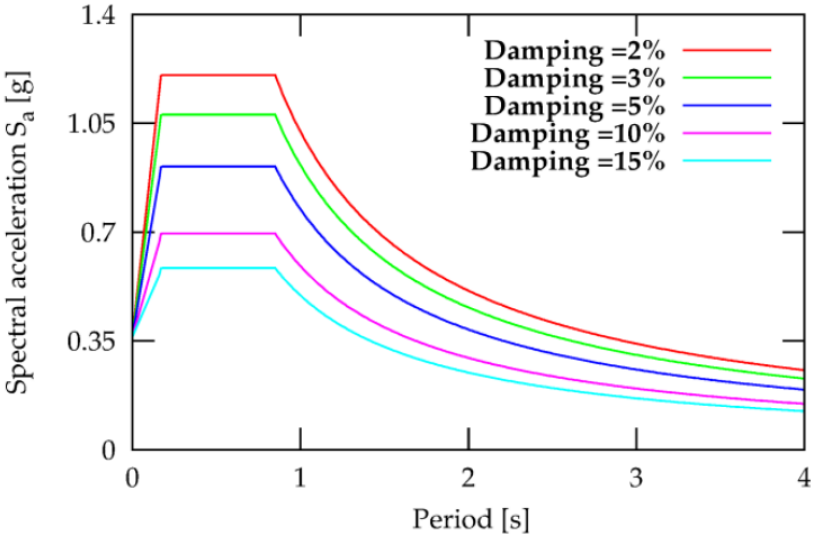
NEW GANDERBAL (RIVERBED)

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.64	0.38	0.42	0.25	0.24	0.16

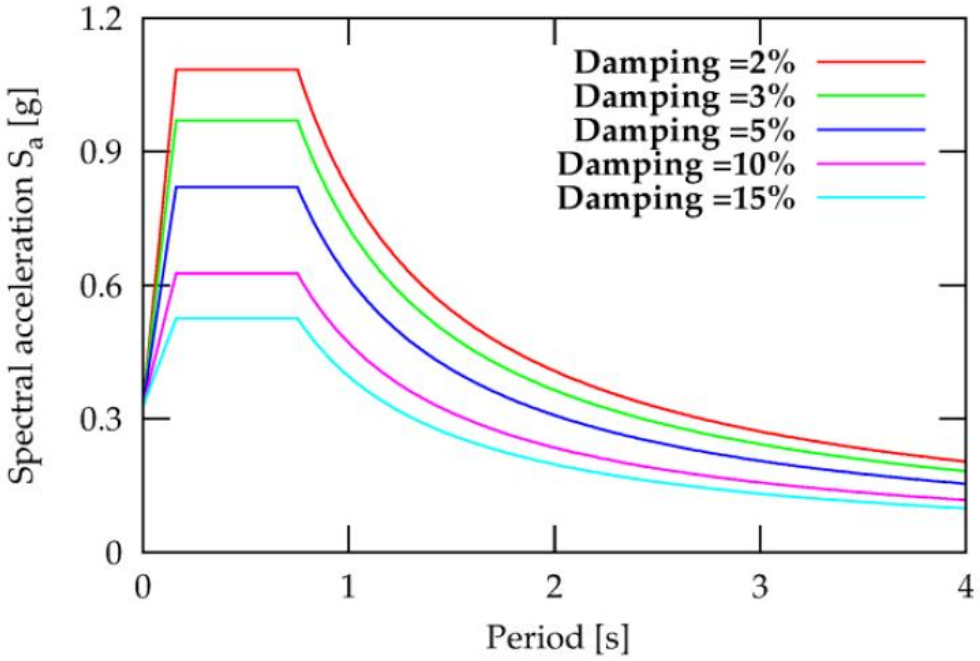
MCE H (RIVERBED)



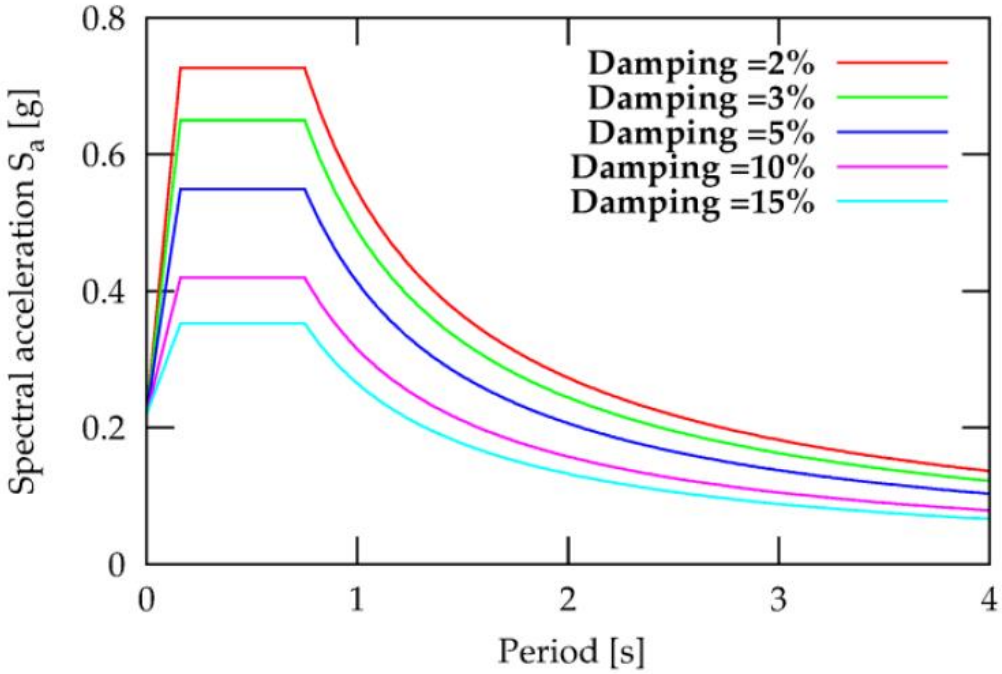
MCE V (RIVERBED)



BDE H (RIVERBED)



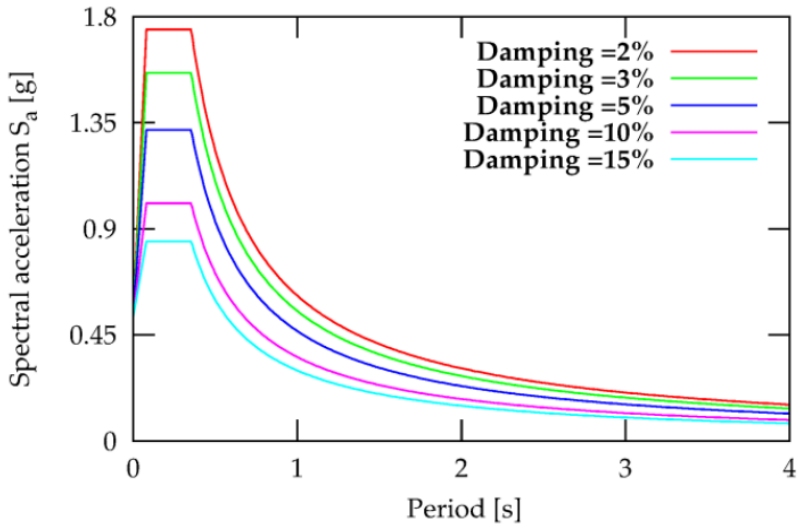
DBE V (RIVERBED)



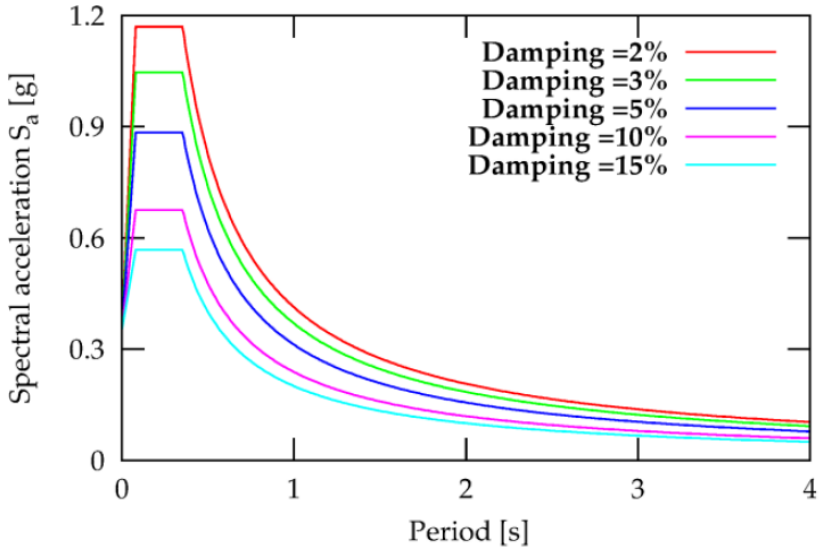
NEW GANDERBAL (BEDROCK)

Magnitude	R_{jb} KM	Focal Depth	PGA(H) MCE	PGA(H) DBE	PGA(v) MCE	PGA(v) DBE	α_h	α_v
8.0	5	15	0.58	0.32	0.38	0.21	0.24	0.16

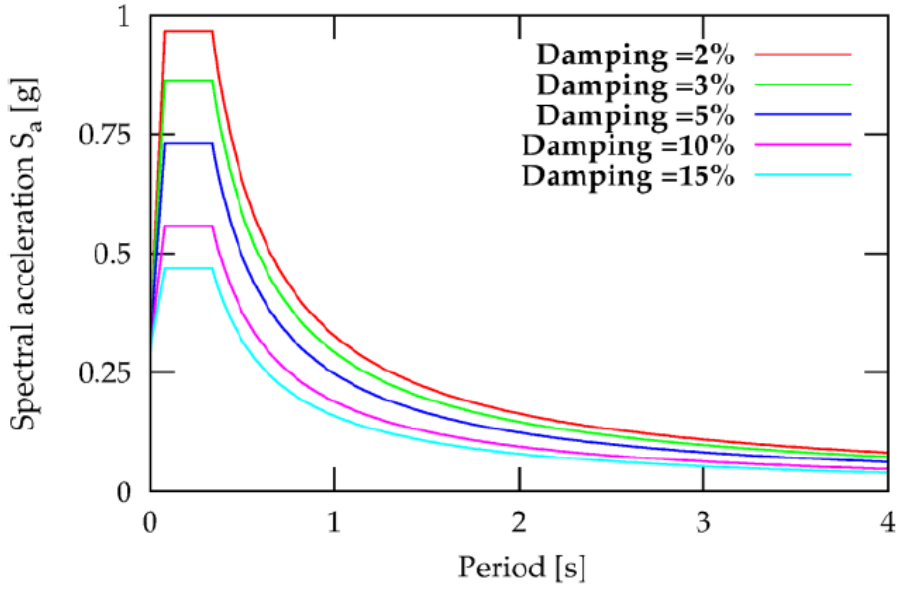
MCE H (BEDROCK)



MCE V (BEDROCK)



DBE H (BEDROCK)



DBE V (BEDROCK)