15 -ാം കേരള നിയമസഭ

4 -ാം സമ്മേളനം

നക്ഷത്ര ചിഹ്നം ഇല്ലാത്ത ചോദ്യം നം. 3031 **18-03-2022 - ൽ മറുപടിയ്ക്ക്**

മുല്ലപ്പെരിയാർ അണക്കെട്ടിന്റെ സുരക്ഷ

ചോദ്യം		ഉത്തരം	
ശ്രീ. സണ്ണി ജോസഫ്		**null** **(ജലവിഭവ വകുപ്പ് മന്ത്രി)**	
(എ)	മുല്ലപ്പെരിയാർ അണക്കെട്ടിന്റെ സുരക്ഷയുമായി ബന്ധപ്പെട്ട് റൂർക്കി ഐ.ഐ.ടി. നടത്തിയ പഠനത്തിൽ അണക്കെട്ടിന്റെ പരിസരത്ത് ഉണ്ടാകുന്ന ഭൂകമ്പങ്ങളുടെ ആഘാതം നേരിടുവാൻ അണക്കെട്ടിന് ശേഷിയില്ല എന്ന് കണ്ടെത്തിയിട്ടുണ്ടോ;	(എ)	ഉണ്ട്
(ബി)	എങ്കിൽ പ്രസ്തുത പഠന റിപ്പോർട്ടിലെ പ്രസക്ത ഭാഗങ്ങളുടെ പകർപ്പ് ലഭ്യമാക്കുമോ?	(ബി)	പഠന റിപ്പോർട്ടിന്റെ പ്രസക്ത ഭാഗങ്ങൾ അനുബന്ധമായി ചേർക്കുന്നു.

സെക്ഷൻ ഓഫീസർ

ഒന്നാമദ്ധ്യായം

EARTHQUAKE ENGINEERING STUDIES

EQD : 2008 - 27

STRUCTURAL STABILITY OF MULLAPARIYAR DAM CONSIDERING THE SEISMIC EFFECTS

PART I- SEISMIC HAZARD ASSESSMENT

DEPARTMENT OF EARTHQUAKE ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247667, INDIA

STRUCTURAL STABILITY OF MULLAPERIYAR DAM CONSIDERING THE SEISMIC EFFECTS

14/2/08
CB

PART I- SEISMIC HAZARD ASSESSMENT

May, 2008

(FOR OFFICIAL USE ONLY)

DEPARTMENT OF EARTHQUAKE ENGINEERING
INDIAN INSTITUTE OF TCHNOLOGYN ROORKEE
ROORKEE-247667, INDIA

PREFACE

Government of Kerala has constituted an Expert Committee for studying the structural stability of Mullaperiyar dam considering the seismic safety vide GO (RT) No. 1087/2007/WRD dated 10.08.2007. The Chief Engineer I& A and ISW approached the Department of Earthquake Engineering, IIT Roorkee for such studies and awarded it. The studies are being carried out in two parts, Part I- Seismic Hazard Assessment for Mullaperiyar Dam Site and Part II- Seismic Safety Analysis of the Composite Dam by Finite Elements Method. This report is about the Part I i.e Seismic hazard assessment.

The present report consists of final report on the recommendations made for the site dependent spectra and the conditions in which the existing dam has to be checked for its safety under MCE condition. Useful discussions held with the officials of I & A and ISW at various stages of study regarding the site specific studies are gratefully acknowledged. Special thanks to Er. N. Sasi, Chief Engineer, Dr. Arun Bapat, Chairman, Expert Committee, Er. M.K. Parameswaran Nair, Member Civil (Retd.), KSEB, Er. A. P. Balan, Superintending Engineer, Er. James Wilson, Asst. Exe. Engineer, KSEB; and Er. G. Anil Kumar, Joint Director, Dam Safety.

The work reported here in was carried out by Dr. D.K. Paul, Professor, Dr. M. L. Sharma, Professor and Dr. J. Das, Scientist at the Department of Earthquake Engineering.

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CONTENTS

6. SEISMIC HAZARD ASSESSMENT AT SITE

The seismic hazard assessment has been carried out by both – deterministic as well as probabilistic approach. The safety of the Mullaperiyar dam has to be checked for MCE conditions for the maximum PGA value arrived at the site. Based on deterministic approach the MCE conditions have been estimated 0.16g at the site. While, using probabilistic approach the MCE conditions have been estimated as 0.21g PGA for 2% exceedance in 50 years. Conservatively, the MCE conditions using probabilistic approach are recommended to be used for checking the safety of the dam.

7. SUMMARY AND RECOMMENDATIONS

1. The Mullaperiyar dam site lies on the western coast of India in the State of Kerala. It lies in Seismic Zone III as per the seismic zoning map of India where a maximum intensity of VII is expected.

2. As the Mullaperiyar dam is more than 110 years old, constructed in stone masonry in lime surkhi mortar, it is envisaged that this old dam will be vulnerable under a future strong motion earthquake in the region and in the eventuality of dam failure may result in human and economical losses.

3. The seismic hazard assessment has been carried out using deterministic as well as probabilistic approach. The safety of the dam has to be checked for MCE condition.

4. The peak ground acceleration value under MCE condition is recommended to be 0.21 g and the corresponding response spectra is given in Fig. 5.

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SEISMIC STABILITY OF MULLAPERIYAR COMPOSITE DAM

DEPARTMENT OF EARTHQUAKE ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
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EARTHQUAKE ENGINEERING STUDIES

EQ: 2008 - 27

SEISMIC STABILITY OF MULLAPERIYAR COMPOSITE DAM

Part II- Structural Stability Analysis

Sponsored by

THE CHIEF ENGINEER, IRRIGATION & ADMINISTRATION and
INTER STATE WATERS, IRRIGATION DEPARTMENT,
GOVERNMENT OF KERALA

EQD- 27 /2008-09

(Final Report)

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DEPARTMENT OF EARTHQUAKE ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGYROORKEE - 247667, INDIA

PREFACE

The Mullaperiyar dam was constructed and completed in 1895 across the river Periyar in the then Travancore State to meet the requirements of irrigation in a Madras Presidency. The Periyar dam is the first composite gravity dam of its kind in the country and also perhaps one of the earliest projects of inter-basin water transfer. Due to occurrence of some recent earthquake in the area, concern about the safety of this 114 years old composite gravity dam was raised. As a result, the seismic safety analysis of Mullaperiyar dam foundation system was referred to the Department of Earthquake Engineering, IIT Roorkee by the Chief Engineer, I & A and ISW, Government of Kerala vide letter No. GO (RT) No. 1087/2007/WRD dated August 08, 2008.

The structural stability of Mullaperiyar dam has been carried out in two parts. Part-I deals with deals with the seismic hazard assessment whereas, Part-II deals with the seismic stability analysis. This study deals with Part-II i.e., the 2D Plain Stress Linear Dynamic Finite Element Model (FEM) Analyses of Main dam as well as Baby dam. In this connection various reports on the study on Mullaperiyar dam conducted by Government of Tamilnadu, Central Water Commission (CWC) and Government of Kerala were provided.

The useful suggestions provided by Er. M.K. Parameswaran Nair, *Chairman, Mullaperiyar Special Cell*, Dr. Arun Bapat, *Chairman, Expert Committee*, Er. P. Lathika, *Chief Engineer, I&A and ISW*, Er. N. Sasi, *Chief Engineer, I&A& ISW*, Er. M. Sasidharan, *Chief Engineer (Rtd.), KSEB*, and Er. James Wilson, *Assistant Executive Engineer, KSEB* are greatly acknowledged.

The investigations have been carried out by Dr. D K. Paul *Professor* and Dr. Pankaj Agarwal, *Associate Professor* in the Department of Earthquake Engineering, IIT Roorkee. Mr. Brijesh Singh, *M. Tech student* and Mr. Rajib Sarkar, *PhD. Scholar*, Department of Earthquake Engineering provided help in conducting the finite element analysis of the Main dam as well as Baby dam in addition to preparation of the technical report.

Dated: October 9, 2009

(D.K. Paul)
Professor

EXECUTIVE SUMMARY

The Mullaperiyar dam is a composite gravity dam built during the period 1887-1895. The front and rear faces of the dam are built with uncoursed rubble masonry in lime surkhi mortar. The hearting, which accounts for 62% of the volume of dam, is constructed of lime surkhi concrete. It lies on the Western Coast of India in the State of Kerala and lies in seismic Zone III as per the seismic zoning map of India. The 53.46 m (176 ft) high composite gravity dam is now more than 114 years old.

Lime surkhi has a tendency of leaching when it comes in contact with water. This process reduces the strength of lime surkhi mortar which reduces the strength of the masonry. In 1930s and 1960s grouting and guniting were done to check the seepage of water from the body of the dam. Concrete backing on the downstream face as strengthening measure was undertaken in 1980s. It is anticipated that ageing effect may have deteriorated the dam material and may have become vulnerable under a future strong motion earthquake and in the eventuality of dam failure human and economical losses may result. It is therefore considered appropriate to assess the safety of the dam under future seismic threat. The complete seismic safety study on structural stability of Mullaperiyar dam has been carried out in two parts. Part-I deals with the Seismic Hazard Assessment and Part-II deals with the Seismic Stability Analysis.

Accordingly, seismic hazard assessment studies at dam site have been undertaken considering the recent increased seismic activities using the current methodology. The details of Part-I study can be found in Ref.2. The Peak Ground Acceleration (PGA) value under Maximum Credible Earthquake (MCE) condition is estimated as 0.21g for 2% exceedance in 50 years.

Here, the details of Part-II studies are presented. The stress analyses of the Main and Baby dams have been carried out by Finite Element Analysis under MCE condition. The safety of dam under various reservoir levels has been studied. Based on the study, recommendations have been made. Both the main and baby dams are found to be unsafe under the Static plus Earthquake (MCE) condition and warrants immediate attention. It is suggested that safety analysis should be ascertained by taking into account the current material properties affected by ageing etc.

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exceeds the maximum static tensile strength of 0.67 N/mm² of random rubble masonry in Baby dam. The maximum tensile stress under static plus earthquake condition at reservoir level 160.22 ft is found to be 0.81 N/mm² which is less than the ultimate seismic apparent tensile strength of 1.34 N/mm². Also the maximum compressive stress developed at the heel of the Baby dam is 1.35 N/mm² which is well within 6.712 N/mm² ultimate compressive strength of random rubble masonry. The Baby dam is found to be safe up to reservoir level of 155 ft. However, at reservoir level 160.22 ft the dam heel may undergo some cracking. The dam is also found to have exceeded maximum tensile strength under static plus earthquake condition, and therefore may undergo some damage at dam heel.

RECOMMENDATIONS AND CONCLUSIONS

1. The earthquake safety of old concrete or masonry gravity dams under moderate to strong ground motions is of great concern. Although there is no evidence of catastrophic failure of gravity dams in past earthquakes, yet the possibility of tensile cracking is never ruled out. The design philosophy in codes requires no collapse under Maximum Credible Earthquake (MCE) condition. The finite element analysis of dam subjected to static and seismic loading shows tensile stresses at the heel of dam-foundation interface.
2. The Main Mullaperiyar dam under DBE condition (corresponds to a seismic co-efficient of 0.12g) under reservoir level of 136 ft, the tensile stresses induced at the dam heel are more than double the permissible value, ie, 1.57 N/mm² against 0.78 N/mm² permissible for RR Masonry.
3. Under MCE condition, the maximum tensile stress at the heel of the dam is of the order of 2.67 N/mm² under the reservoir level of 136 ft, which far exceeds the ultimate apparent seismic tensile strength of 0.78 N/mm². On the basis of the above study it is found that the static tensile stresses and combined static

plus earthquake tensile stresses at heel of the Main dam exceed the average ultimate tensile strength of RR masonry (provided by the Irrigation Department of Kerala), and therefore the Main dam during static plus Earthquake (MCE/DBE) condition is likely to undergo damage.

4. The Baby dam under static plus earthquake condition up to reservoir level of 155 ft is found to be safe. For probable maximum flood which will cause reservoir level to rise up to 160.22 ft, the Baby dam may undergo some cracks at the dam heel. Under static and earthquake loading conditions for Maximum Considered Earthquake (MCE), the tensile stress at dam heel exceeds the maximum apparent seismic tensile stress and therefore the random rubble masonry of the Baby dam is likely to undergo damage.

5. Based on the analysis, both the Main Mullaperiyar dam and Baby Dam are likely to undergo damage which may lead to failure under static plus earthquake condition and therefore needs serious attention.

6. Most of the values adopted here for material properties are based on the tests conducted some 20 to 25 years back. During this period this dam has definitely gone through considerable deterioration due to ageing and weathering. As such the assumed parameters may be naturally higher than the insitu condition. Proper assessment of existing material properties is very important for the safety assessment. It is therefore recommended to carry out further testing on the dam and foundation materials.

Rashmi