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# A REVIEW OF PREVIOUS WORK ON AN APPROACH TO ANALYSIS AND DESIGN OF GRAVITY DAM

**Prof. M. M. Lohe*1, Komal Mankar*2**

*1Professor, Department of Civil Engineering, BapuraoDeshmukh Collage of Engineering Sewagram, Wardha.

*2Post Graduate Student Structural Engineering, BapuraoDeshmukh Collage of Engineering Sewagram, Wardha.

## ABSTRACT

This paper present the design and stability analysis of lower wardha dam (a concrete gravity dam situated in wardha river at varud (Baggaji) Dhanodi near arvi in wardha district ). Through, the demanding years, it has been observed that failures of dams due to many factor are common. So it is the essential to analysis the dam against all its modes of failures, forces acting on it, uncontrollable disasters such as earthquake, etc. for this, the preliminary data of the dam required for design, such dimensions, base width, crest width, etc. was collected through the inspection engineer, posted at dhanodi lift irrigation office, pipri, dist. Wardha. On the basic collected data the elementary profile and practical profile of dam was estimated. Further all major and the minor force forces acting on dam were calculated, stability analysis of designed dam against all modes of failure and for various load combinations was carried out in STAAD PRO software and was checked permissible limits.Dam structures that span navigable waterways are inherently at a risk for seismic vibrations and as such they must be designed to resist these vibrations. These are very complex structures and subjected to various types of forces in nature. Evaluation of concrete gravity dam for earthquake loading must be based on appropriate criteria that reflect both the desired level of safety and choice of the design and evaluation procedures. In India, the entire country is divided into 3 seismic zones, depending upon the severity of earthquake intensity. Thus main aim of this Project analysis of high concrete gravity dam based on the U.S.B.R. recommendations in seismic zone 2 of India, for varying horizontal earthquake intensities from 0.10 g – 0.30 g with 0.05 g increment to take into account the uncertainty and severity of earthquake intensities and constant other design loads, and to analyze its stability and stress conditions using analytical 2D gravity method and finite element method. Analysis of concrete gravity dam by STAADPRO.

**Keywords:** Concrete Gravity Dam, Lower Wardha Dam, Analysis of Dam in STAAD PRO, Earthquake Intensities as per U.S.B.R. Recommendations in seismic zone 2, IS: 1893-1984Analysis of solid gravity dam as per IS:6512-1984.

## I. INTRODUCTION

Any structure that is constructed will undergo many forces such as wind, seismic, self-weight or forces like ice/snow etc. Among these, seismic forces are natural and as we know earthquake is a natural calamity and is so unpredictable.in order to prevent the structure from being collapse, it's very important to adopt earthquake resistant design philosophy while designing the structure. Waves which arises during seismic event carries very massive speed and when it struck with any structure it travels through foundation to the top roof resulting In-elastic deformation. There may be the possibilityof collapse of whole structure or probably it will survive depending upon the design adopted but surely the structure will be costly. Sometimes damages caused by earthquake vibrations very high that goes beyond repairs works. Generally hydraulic structure like concrete gravity dam, canals and RCC multi-storeyed structures are sufficiently stiff and ductile. Concrete gravity dam is a massive structure having many forces acting on it. It's very important for the dam to survive against seismic vibrations. This paper is mainly focused on behaviour of concrete gravity dam with earthquake intensities as per U.S.B.R. recommendation.In order to study the precise behaviour of structures, finite element method plays an important role. These analyses methods can be adopted to study the structures having single degree of system or multi degree of freedom system possessing non-linear characteristics.

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**Concrete gravity dam** concrete gravity dam is a solid structure which is made up of concrete or masonry. It acts as a water retaining structure and holds a large amount of water by creating a reservoir on its upstream side. That's why gravity dam is constructed across a river for retaining of water. The cross section of the gravity dam is approximately triangular in shape and having an apex at top and maximum width at bottom. There are various forces acting on the gravity dam mainly hydrostatic pressure, silt pressure, wave pressure, ice pressure, wind forces, self- weight of the dam, uplift pressure and seismic forces etc. The section of the dam is designed in such a way that it would resist all these forces acting on it from various directions under the effect of its own self weight. Gravity dams are also called as solid gravity dams because they are rigid as well as solid and no bending stresses are induced at any point on a dam structure. They are generally straight in plan the upstream face is vertical and slope of downstream face is 0.7:1. For construction , the need good foundations topography to perform better throughout in its lifetime.

**About the software : STAAD** or (STAAD.PRO) is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda, CA. in late 2005, Research Engineer International was bought by Bentley Systems. An older version called-III for windows is used by lowa State University for educational purposes for civil and structural engineers. The commercial version STAAD. Pro is one of the most widely used structural analysis and design software. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis.

**Finite Element Modeling of The Dam,** the dam body is modeled in STAADpro using the solid isoparametric finite element with eight nodes. Each node has three translational degrees of freedom. The stiffness matrix of the solid element is evaluated by numerical integration with eight Gauss – Legendre points. The dam is analyzed for several basic loads and loads combinations possibly met with during its service. The stresses induced are checked for all the combinations and the dimensions.

## II. LITERATURE REVIEW

Gravity dam is designed for various forces especially for the overturning moment and for the sliding forces. Proper design is also required to safeguard earthquake which is a severer problem in the design of concrete gravity dam.

**Mettu Rajesh Reddy, M. Nageshwar Rao (2017) on "Design of Analysis of Gravity Dam- A Case Study Analysis Using Staad-Pro". Volume 2, Issue 4** In this paper, the section of gravity dam approximately triangular in shape, with its apex at its top and maximum width at bottom. The section is so proportioned that it resist the various forces acting on it by its own weight. In this paper analysis of dam is carried out using Staad.Pro software.

**Dr.Bakenaz A. Zeidan(2014) on "State of Art in Design And Analysis of Concrete Gravity Dams".** In this paper, Dam has been constructed for millennia, influencing the lives of humans and the ecosystems they inhabit. Remnants of one such man-made structure dating back 5000 years are still standing in northeast Africa (UNESCO- WWAP, 2003). Older existing dams may fail to meet revised safety criteria and structural rehabilitation to meet such criteria may be costly and difficult. The identified causes of failure, based on a study of over 1600 dams[1]are: foundation problem (40%) inadequate spillway (23%), poor construction (12%), uneven settlement (10%), and high pore pressure (5%), acts of war (3%), embankment slips (2%), defective materials (2%), incorrect operation (2%) and earthquake (1%). However, the structural response of material to different loads determines how it will be economically utilized in the design process.

**Mr. Manoj Nallanathel, Mr. B. Ramesh, and AB. Pavan Kumar Raju (2018) on "Stability Analysis Of Concrete Gravity Dam". International Journal of Pure and Applied Mathematics, volume 119 No. 17** In this paper mainly tell about the strength of material is important when the concrete gravity dam is analyzing stability and seismic pressure. This project basically gives the analysis of stability of concrete gravity dam by using Staad. Pro and conventional methods. Staad. Pro is computer software, which is used for stability and stress analysis of structures. Dam is such a massive structure: to evalute such structure manually is very tedious and long timing process so it's easy to evalute the dam stability Staad. pro.

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**Miss. Meghna S. Bhalodkar (2014) on "Seismic & Stability Analysis of Gravity Dam"** In this paper, the stability analysis of the dam but not considered the seismic analysis of the dam. The stability analyzed by calculating the moments, frictional force, shear friction force. It is observed that value of vertical forces increases value of horizontal forces which resulted in instability against sliding.

**T Subramani, D. Ponnuvel (2012) on "stability analysis of gravity dam using Staad pro"**In this paper, present the stress analysis of gravity dams is performed to determine the magnitude and distribution of stresses throughout the structure for static and dynamic load condition and to investigate the structural adequacy of the substructure and foundation. The Staad pro provided the most appropriate values to learn or investigate a constructed dam or pre constructed dam. He say that the computations are very difficult to perform, due to coupling between the uplift pressure and the cracking length.

**S. Sree Sai Swetha and G. Ganesh Naidu (2017) On "Seismic and Stability Analysis of Gravity Dams Using Staad Pro"** In this paper present the main features and organizationStaad Pro, a computer program that has been developed for the static and seismic stability evaluations of concrete gravity dams. Staad pro is based on the gravity method using rigid body equilibrium and beam theory tp perform stress analyses, compute crack lengths, and safety factors. Seismic analyses could be done using either the pseudo-static or a simplified response spectrum method. Staad pro is primarily designed to provide support for learning the principles of structural stability evaluation of gravity dams. It could also be used for research and development on stability of gravity dams. In adopting several worldwide published dam safety guidelines, a large number of modelling options have been implemented regarding (a)crack initiation and propagation, (b) effects of drainage and cracking under static, seismic, and post-seismic uplift pressure conditions, and (c) safety evaluation formats. Structural stability evaluation of a 30m dam is presented to illustrate the use of Staad pro that is available free from the web site.

**Pratik Patra NIFTR (2014) ON "Development of Methodology For Seismic Design of Concrete Gravity Dam"** In this paper, Earthquake analysis and earthquake resistance design is of major importance because of the catastrophic consequence if such a structure is to fail. In India we don't have any guidelines to take into account the seismic load for the analysis of Dam. In the absence of any well-defined method, design offices generally use an empirical method which does not consider the dynamic properties of dam and different earthquake zone. This study is an attempt to develop guidelines to consider seismic force for the analysis of concrete gravity dam. An equivalent static method for seismic design of concrete gravity dam is developed considering the dynamic properties of the dam as well as different earthquake zone. For this to achieve, a family of concrete gravity dam with varying height, base-width and side slope is analysed using finite element software ANSYS. Dams are modelled with 2-D plane strain elements. Dynamic properties of all the selected dams are evaluated. A regression analysis is carried out on the modal properties obtained from the finite element analysis in order to develop empirical relation between time period, height and base width. The minimum number of modes that must be taken into for the analysis is decided by considering the mass participation ratios. Design base shear is calculated by using the Design horizontal acceleration spectrum value and seismic weight of the building. A method is proposed to distribute the calculated base shear over the height of the Dam.

**Moftakhar, H. R. Ghafouri (2011) on "Comparison of stability Criteria for Concrete Dams in Different Approximate Methods Based on Finite Element Analysis"** Inthis paper, Different regulations for the design of concrete dams suggest various criteria for stability control of dams. Some of these criteria, which are conservative, lead to the over-design of dam sections. By using the finite element method, which is considered more accurate than many, this research is intended to determine the accuracy of approximate methods and compare them with each other.

**Jay P. Patel, R. Chhava (2015) on "Analysis of Concrete Gravity Dam by 3d Solid Element Modelling Using Staad Pro"** In this paper, 3d modelling and analysis of gravity dam of solid element using Staad Pro. The loads and the load combination are international journal of pure and applied mathematics special issue 290 consider as per 6512. In this paper, directly analysed the dam by solid elements using Staad Pro. There are some

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uncertainties still prevailing regarding stability at support conditions. In this paper, solid foundations are considered to avoid this situation.

**Mohamed RagabElprinceElmenshway (2015) on "Design and Analysis of Concrete Gravity Dams"**In this paper, Concrete dams are vital structures regarding catastrophic impacts in cases of dam failure. Safety of dams should be investigated quite critically by logical and precise methods. The fluid- structure-foundation interaction is one of the main factors that affects dam's behaviour during earthquake excitations. The analysis of dam-reservoir-foundation coupled system is a complicated phenomenon due to interaction among reservoir water, rock foundation and concrete dam. Static and dynamic simulation of concrete gravity dams should cope with the variation of foundation mass, foundation stiffness, ground motion excitation and geometry of both dam and reservoir. The objective of the present study is to assess static and seismic responses of concrete gravity dams due to key parameters that affect behaviour of dams.

**Khalid Dawlatzai, Dr. Manju Dominic (2018) on "Structural Stability And 2d Finite Analysis of Concrete Gravity Dam"** In this paper, Gravity Dams are important lifeline structure and represent the fragrance of people's standard of living. Dam structure that span navigable waterways are inherently at a risk for seismic vibrations and as such they must be designed to resist these vibrations. These are very complex structures and subjected to various types of forces both static and dynamic in nature. Conventional 2dimensional methods are used for the preliminary analysis are over-estimated, it is still useful for the preliminary analysis. In this work a 2dimensional stability analysis of a non-overflow section of the koyna dam having maximum height of 103 m and base width of 70m is done first using the gravity method of analysis which is a rational analysis method.

**E. Yildiz& A.F. GurdilTemelsu International Engineering Services Inc., Ankara, Turkey. Review on Seismic Design of Concrete Gravity or RCC Dams** It is not economical to increases the strength requirements because of the stress concentrations at areas where abrupt geometry changes are inevitable. There may be considerable permanent displacements along the assumed considerable permanent displacements along assumed cracking surface in case MDE loading. However, these deformations and the relevant damage may be considered as acceptable where the inelastic behavior is evaluated in a realistic way by advanced analysis methods, and the stability of the dam or critical blocks are satisfied during and after the earthquake considering the post- earthquake material and load conditions and possible aftershocks.

## III. RESULTS AND DISCUSSIONS

By Reviewing of the findings and conclusions of the various reputed researches, it could be understand the importance of site selection, structural designing, selection of appropriate materials and various aspects related to gravity dams constructions. The guidelines Laid down by Tim Stephens about the design and construction of gravity dam is found very useful. He restrict to the construction of earth dams higher than 5m from streamed to finished crest level. Dams on catchment areas exceeding 25km$^2$ or with reservoir areas storing more than 50000 m$^3$ may require the advice of a hydrologist to assist in the design of spillway and other outlets and for the estimation of freeboard. It is also found useful the suggestions of Mettu Rajesh Reddy, M. Nageshwar Raothe section of gravity dam approximately triangular in shape, with its apex at its top and maximum width at bottom. The section is so proportioned that it resist the various forces acting on it by its own weight. In this paper analysis of dam is carried out using Staad.Pro software. It is relevant here to mention the work carried out by Dr.Bakenaz A. ZeidanOlder existing dams may fail to meet revised safety criteria and structural rehabilitation to meet such criteria may be costly and difficult. The identified causes of failure, based on a study of over dams. It will also be useful here to quote the study carried out byDifferent regulations for the design of concrete dams suggest various criteria for stability control of dams. Some of these criteria, which are conservative, lead to the over-design of dam sections. By using the finite element method, which is considered more accurate than many, this research is intended to determine the accuracy of approximate methods and compare them with each other. By studying a no of researches carried out by the learned reserachers we found that they are all concerned to dam design and analysis on such a site where there are no water present at work site or the construction site is first vacated by the construction of coffer dam and others. As concern to the dam analysis and design of gravity damare Conventional 2dimensional methods are used for the preliminary

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analysis are over-estimated, it is still useful for the preliminary analysis. In this work a 2dimensional stability analysis of a non-overflow section of the koyna dam having maximum height of 103 m and base width of 70m is done first using the gravity method of analysis which is a rational analysis method. Discussed byKhalid Dawlatzai, Dr. Manju Dominic.

## IV. CONCLUSION

A challenge was arisen to construct a dam in wardha river at varud (Baggaji) Dhanodi near arvi in wardha district to fullfill two objectives :-

This chapter deals with numerous of literature that have been found helpful for carrying out of the work. In above literature review earthquake intensities are not added in horizontal as well as vertical direction as per the Indian sesmic zone 2. So in this project I will considered 0.1g varying with horizontal earthquake force and 0.05 g varying with vertical earthquake forces. This literature review provides the guidelines to carry out analysis gravity dam by analytically and using STAAD PRO, Software.

## V. REFERENCES

[1] Mettu Rajesh Reddy, M. Nageshwar Rao (2017) on "Design of Analysis of Gravit Dam- A Case Study Analysis Using Staad-Pro". Volume 2, Issue 4

[2] Dr.Bakenaz A. Zeidan (2014) on "State of Art in Design And Analysis of Concrete Gravity Dams"

[3] Mr. Manoj Nallanathel, Mr. B. Ramesh, and AB. Pavan Kumar Raju (2018) on "Stability Analysis Of Concrete Gravity Dam". International Journal of Pure and Applied Mathematics, volume 119 No. 17

[4] Miss. Meghna S. Bhalodkar (2014) on "Seismic & Stability Analysis of Gravity Dam"

[5] T Subramani, D. Ponnuvel (2012) on "stability analysis of gravity dam using Staad pro"

[6] S. Sree Sai Swetha and G. Ganesh Naidu (2017) On "Seismic and Stability Analysis of Gravity Dams Using Staad Pro"

[7] Pratik Patra NIFTR (2014) ON "Development of Methodology For Seismic Design of Concrete Gravity Dam"

[8] Moftakhar, H. R. Ghafouri (2011) on "Comparison of stability Criteria for Concrete Dams in Different Approximate Methods Based on Finite Element Analysis"

[9] Jay P. Patel, R. Chhava (2015) on "Analysis of Concrete Gravity Dam by 3d Solid Element Modelling Using Staad Pro"

[10] Khalid Dawlatzai, Dr. Manju Dominic (2018) on "Structural Stability And 2d Finite Analysis of Concrete Gravity Dam"

[11] E. Yildiz& A.F. GurdilTemelsu International Engineering Services Inc., Ankara, Turkey. Review on Seismic Design of Concrete Gravity or RCC Dams Khalid Dawlatzai, Dr. Manju Dominic (2018) on "Structural Stability And 2d Finite Analysis of Concrete Gravity Dam" E. Yildiz& A.F. GurdilTemelsu International Engineering Services Inc., Ankara, Turkey. Review on Seismic Design of Concrete Gravity or RCC Dams