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A Critical Review on Design of RCC Cantilever Retaining Wall

Taring Sanjay[1], Talkeshwar Ray[2]
[1]M-Tech. Student Department of Civil Engineering, Himalayan University Itanagar, Arunachal Pradesh, India
[2]Assistant Professor Department of Civil Engineering, Himalayan University Itanagar, Arunachal Pradesh, India
Corresponding author : - Taring Sanjay

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ABSTRACT

This paper provides an innermost and the dynamics role of the RCC Cantilever Retaining Wall in soil strata of different region especially on hilly and mountainous area of Himalayan range, analysis depending upon the previous research paper done by using different software. As we live on 21st century a result of population boom and new technology of different engineering properties developed day to day life. This is the major issue especially in the case of developing country where lot of earthwork is being carryout. Highway Bridges, flyover, Tunnel, Dams, Reservoirs and Cannels are constructed and developing rapidly in the big cities as well as in the countryside, making the study of RCC Cantilever Retaining Wall as an essential part of structural design process to Control flood, landslide of backfilling and natural Phenomena and for the economic purpose. The effect, on which the structures stands, especially in the highly seismic zones, the dynamic behavior of soil as well as retaining structure, should be well known by the designer. The effects of structures standing in a steep slope to each other are the main issue of cantilever retaining structure, as well as by-soil-structure interactions. In this paper, various methods of RCC Cantilever Retaining structure are carried out by various researchers in different software.

Keywords :- RCC Cantilever Retaining Wall, Developing Country, Highway, Bridges

I. INTRODUCTION

Various attempts have been made by different researchers to model the cantilever retaining wall problem analytically by different software such as AutoCAD, Staad-Pro, SAFE, RISA, 3D environmental, Naviswork, ETABS, RIVET, MATLAB etc; however the nonlinearity, foundation interfaces and certain boundary conditions of software make the problem more complex, and computationally uneconomical. Also the rapid evolution of material such as cement of different characteristic strength, quality, Plasticizer and manufacturing of reinforcement with different Grade such as (250,450,500,550) etc and with diameter of (8, 12, 16, 20, 25 and so on) also lead to diverse situation in design and construction of retaining wall.

II. REVIEW OF AVAILABLE LITERATURES

Prachi S. Bhoyar1, Dr. G. D. Awachat:-This paper presents the Static analysis and Design of retaining wall with and without shelves. Cantilever retaining wall with pressure relief shelves is considered as a special type of retaining wall. The concept of providing pressure relief shelves on the backfill side of a R.C.C retaining wall reduces the total earth pressure on the wall, which results in a reduced thickness of the wall and ultimately in an economic design of a cantilever wall. The conclusions in this thesis drawn based on the discussion and results obtained analytically and using Staad-Pro. model study. The pressure distribution diagram changes much due to addition of shelves. The pressure relief shelves have been extend up to the failure plane to achieve the stability of the structure. In practice, there is limitation of using more number of shelves, but up to three shelve may be used economically for high retaining walls. It is also observed that, the average saving in cost of construction is 15% to 25% by the provision of relief shelves over the conventional cantilever retaining wall. Analytical results of active earth pressure, nodal reactions, and bending moments with pressure relief shelves have been close agreement with the Staad-Pro. Software result.

Rajesh D. Padhye, Prabhuling B. Ulagaddi (2010): They used active earth pressure and lever arm in their study and found reduction of shelf and there by considerable reduction the moment about the base slab.

Dr. D. N. Shinde, Mr, Rohan R. Watve (2015): This paper concerned with the analysis of cantilever retaining wall using Finite Element method. The retaining wall with and without shelves is analysed by using Stadd-pro model and results for various parameters was compared and found satisfactory.

Basudhar et al. (2006):- investigated the efficient cost design of cantilever retaining walls of a particular height that satisfies the constraints of some structural and geotechnical designs. Seven design variables were taken into consideration, which are base width, toe width, thickness of stem, thickness of base, minimum width of embedment, reinforced rod diameter and top width of stem. The method of sequential unconstrained minimization along with Powell's algorithm for multidimensional searches and the method of quadratic interpolation for one dimensional search were adopted. It was noticed that by increasing the top of the stem from 10 to 30cm, the cost was increased by 9% to 15%.

Robert F. Bruner, Harry M. Coyle, and Richard E. Bartoskewitz :-In this paper currently available retaining wall design procedures ware summarized with emphasis on the prediction of lateral earth pressures using the Coulomb and Rankine earth pressure theories, and the equivalent fluid pressure method. The information presented in their report was obtained during the last three years of a five year study on "Determination of Earth Pressures for Use in Cantilever Retaining Wall Design". Measured pressures and movements along with results of geotechnical tests of the foundation and backfill soils are presented in detail. The test wall design based on the District 12 TSDHPT design standard is outlined and compared with results from the field performance study. Significant modifications were made in the areas of the use of cohesive soil in the backfill, the computation of lateral earth pressures, and the computation of stability against overturning. This objective has been accomplished and the proposed modifications in design procedure are based on measured earth pressures, measured wall movements, and measured geotechnical properties of the soils adjacent to the wall. The measured earth pressures on the heel (back) side of the wall were greater than those predicted by current design procedures. A proposed uniform pressure of 2 psi and an earth pressure coefficient of unity are indicated for use in the proposed design modifications. The measured earth pressure on the toe (front) was 3.5 times greater than the pressure measured on the heel (back) at the same depth. Also, significant earth pressure was measured on the front of the key. These pressures contribute to the stability of the wall against sliding and overturning. The measured pressures along the base of the footing were nearly uniform because of foundation soil resistance which contributes to stability against overturning. This contribution is included in the proposed design modifications. Total horizontal movement measurements indicated that most of the movement occurred during the construction backfilling process. Vertical movement and tilt measurements were relatively small because iv of the stiff clay foundation soil. The undrained shear strength is recommended in the modified design procedure because it is the appropriate strength parameter during construction. The proposed modification in design procedure should be verified by additional field performance studies. These studies should include walls with different proportions that are founded on and backfilled with different soil types. This report contains recommendations for instrumentation on future field studies.

D.R. Dhamdhere1, Dr. V. R. Rathi2, Dr. P. K. Kolase: -This paper consist of analysis and design of cantilever and relieving platform retaining wall with varying height from 3m to 10m and SBC 160KN/m^2. It also shows comparative study such as cost, economy, bending moment, stability against overturning &sliding between both the retaining wall. The comparative study is carried out along with the cost and optimum or least cost estimate is chosen as the best option. In this paper it is also shown that the relieving platform retaining wall is economical, more stable than cantilever retaining wall and it also relives the bending moment of heel portion.

Poursha et al. (2011):- studied the optimum cost of the reinforced cantilever retaining wall of satisfying a number of geotechnical and structural constraints using harmony search algorithms. The design variables were the stem thickness at the top, the stem thickness at the bottom, toe width, heel width, stem height, base slab thickness and key depth. The object function was to minimize total cost of the design and construction according to ACI 318-05. The procedure of optimum design was divided into two stages. Firstly, checking for stability, which included overturning, sliding and bearing capacity failures? Secondly, checking each part of the cantilever wall for the strength and required steel. The same process of Athens Journal of Technology and Engineering September 2018 279 optimization was repeated for two types of backfill using MATLAB, and the mathematical results showed that the solution of improved harmony search algorithm was better, when compared to a traditional harmony search method.

Pei and Xia (2012):- followed heuristic optimization algorithms to design a reinforced cantilever retaining wall. The main goal of this investigation was to design the wall with minimum cost of the retaining wall which comprises the cost of concrete and reinforcements per meter length of the wall. The costs of labours, framework, steel fixing and losses of material were neglected for sake of simplicity. Three types of heuristic algorithms were approached for solving the constrained model of optimization including Genetic Algorithm (GA), Particle Swarm Optimization (PSO) and Simulated Annealing (SA). The main outcome was that the application of heuristic optimization algorithms is very effective in the design of a reinforced cantilever retaining wall with minimum cost. It was recommended that the particle swarm optimization was the most effective and efficient among the three methods used. With regard to cost, it was found that the design gained by the method of heuristic optimization algorithms was half as expensive as the traditional design method.

Dr. P. D. Hiwase Mr. Shashank Bisen Mr. Pratik Surana:- this paper, want to make an attempt to use programming languages to make calculations of the design of retaining wall much more easy and swift. Retaining walls are used to retain earth or other loose material. These walls are commonly constructed in the places namely construction of building basement, as wing wall or abutment in bridge construction and in the construction of embankment. All these types of construction works require intricate calculations with accuracy and precision. So to make these calculations much easy and appropriate, the use of a programming language known as Python is used here. The earth retaining wall is the most important structure in various construction projects of civil engineering. It involves intricate design work and the manual calculations can sometimes become tedious and time taking. Also the accuracy and precision of the design becomes very important when it comes to big structures such as bridges and dams. Therefore, a lot of companies and construction firms have started using various user friendly software.

Ali Kaveh1, Kiarash Biabani Hamedani, Taha Bakhshpoori :-In this paper, optimum design of reinforced concrete cantilever retaining walls is performed under static and dynamic loading conditions utilizing eleven population-based meta-heuristic algorithms. These algorithms consist of Artificial Bee Colony algorithm, Big Bang-Big Crunch algorithm, Teaching-Learning-Based Optimization algorithm, Imperialist Competitive Algorithm, Cuckoo Search algorithm, Charged System Search algorithm, Ray Optimization algorithm, Tug of War Optimization algorithm, Water Evaporation Optimization algorithm, Vibrating Particles System algorithm, and Cyclical Parthenogenesis Algorithm. Two well-known methods consisting of the Rankine and Coulomb methods are used to determine lateral earth pressures acting on cantilever retaining wall under static loading condition. In addition, Mononobe-Okabe method is employed for dynamic loading condition. The design is based on ACI 318-05 and the goal of optimization is to minimize the cost function of the cantilever retaining wall. The performance of the utilized algorithms is investigated through an optimization example of cantilever retaining wall. In addition, convergence histories of the algorithms are provided for better understanding of their performance

Sheikholeslami et al. (2014):- In this paper, author developed a novel optimization technique known as hybrid firefly algorithm with harmony search technique (IFA–HS) in order to obtain the optimal cost of reinforced concrete retaining walls satisfying the stability criteria and design provisions of ACI 318-05. Some design examples were tested using this new method from which the results confirmed the validity of the proposed algorithm. The method demonstrated its efficiency and capability of finding least-cost design of retaining walls that satisfy safety, stability and material constraints.

Medhekar (1990) investigated the optimum design of free cantilever retaining walls. Two different types of foundation were assumed which are rigid and flexible. The objective was to minimize the total cost of the structure. The method of the interior penalty function was used to solve the problem of nonlinear optimum design. The requirement for the stability and structural strength were represented as constraints. The results showed that the minimum cost of a wall with a height varying from 3 to 6m for the rigid foundation was slightly higher than for a corresponding wall and flexible foundation. This means that the flexibility of the foundation has no significant effect on the cost of retaining walls.

Jyoti P. Bhusar & Rajashri S. Ghodke: - This paper presents the parametric study to recognize the effect of number of shelves, width of shelves and shelf position on the lateral earth pressure distribution, top wall movement and the maximum bending moment on the wall with shelves. Reduction in lateral thrust due to provision of relief shelf reduces the bending moment at the stem bottom. The present study reveals that the cantilever retaining wall with single relief shelves can reduce bending moment at the bottom of stem up to 70%, compared to that of a retaining wall without relief shelf. The economic shelf location for cantilever retaining wall with single shelf is at 0.4h to 0.5h from top of the stem, where h is height of stem. The deflection of the stem is reduced by about 95% by providing shelf. Retaining wall with two shelves of 1.5 m and 2 m shelf widths positioned at 0.35h and 0.55h is recommended and it decreases bending moment at bottom of stem by about 65% and top node displacement by about 70%. Retaining wall with two shelves 2 m and 2.5 m shelf widths positioned at 0.35h and 0.65h shows better performance and it decreases bending moment by about 78% as well as decreases node displacement by about 90% along with nearly uniform earth pressure beneath the base slab.

Yaoyao Peia , Yuanyou Xia, a: -This paper aims at automatic design and cost minimization of reinforced cantilever retaining walls (RCRW). The design requirements and geometrical constraints are imposed as design constraints in the analysis. 9 parameters are selected to define the structure and 25 constraints are established. Three heuristic algorithms, including genetic algorithm (GA), particle swarm optimization (PSO) and simulated annealing (SA) are presented to solve the constrained optimization model. The computation programs have been developed and validated by taking an example design. Results show that heuristic optimization algorithms can be effectively applied to cost minimization design of RCRW. It is found that no single algorithm outperforms other methods. With respect to effectiveness and efficiency, PSO is recommended to be used.

Akshaykumar S. Chalakh, Prof. Sanjay Bhadke :- Investigating the presentation of earth holding structures under seismic conditions has been significant issue because of their wide applications in a few infrastructural applications and different structures. The issue of unsteadiness of dividers is predominantly identified with earth pressure circulation on the divider and the reaction of divider against the earth pressure, particularly, under unique stacking condition. Soil – divider collaboration is a significant property which oversees the dynamic conduct of the divider. Much after an enormous number of studies, the dynamic conduct of soil-divider framework is as yet not totally explaining. The target of this examination is to contemplate the seismic conduct of L-Shape cantilever holding divider alongside the earth pressure dissemination of soil in seismic conditions. There are a few sorts of holding divider and the most widely recognized sorts utilized are gravity divider, cantilever divider, counter post dividers and buttressed divider. In this manner, a couple of parts should be utilized so as to get the goal. Thus, this framework can be utilized for the plan of a cantilever holding divider. In addition, it spares time in the plan with adequate format detail of the cantilever holding divider. Right now of L-Shape cantilever holding dividers includes strength checks for toppling, sliding and bearing.

Tamadher Abood1, Hatem E.Younis Eldawi, Faeza R. Elnaji Abdulrahim :-Retaining structures hold back soil or other loose material where an abrupt change in ground elevation occurs. The retained material or backfill exerts a push on the structure and thus tends to overturn or slide it, or both. The cantilever is the most common type of retaining wall and is used for walls in the range of 3to 6m in height. This study presents analyses and design of cantilever retaining wall which is made from an internal stem of steel-reinforced, cast-in-place concrete (often in the shape of an inverted T). In this work a detailed analyses and design for this type of walls which include estimation of primary dimensions of the wall, then these dimensions were checked. The factor of safety against sliding, overturning and bearing were calculated the shear resistance for the base, the tension stresses in the stem and the tension stresses for the base were checked. Calculation of reinforcement for each part of the wall was done. All analysis and design are based on the ACI cod

Russell A. Green & C. Guney Olgun & Wanda I. Cameron: - A series of nonlinear, explicit finite difference analyses were performed to determine the dynamic response of a cantilever retaining wall subjected to earthquake motions. This article outlines the calibration and validation of the numerical model used in the analyses and comparisons are presented between the results from the finite difference analyses and results from simplified techniques for computing dynamic earth pressures and permanent wall displacement (i.e., Mononobe-Okabe and New mark sliding block methods). It was found that at very low levels of acceleration, the induced pressures were in general agreement with those predicted by the MononobeOkabe method. However, as the accelerations increased to those expected in regions of moderate seismicity, the induced pressures are larger than those predicted by the Mononobe-Okabe method. This deviation is attributed to the flexibility of the retaining wall system and to the observation that the driving soil wedge does not respond monolithically, but rather responds as several wedges. It was found that the critical load case for the structural design of the wall differed from that for the global stability of the wall, contrary to the common assumption made in practice that the two load cases are the same.

Parishad Rahbari, Nadarajah Ravichandran, and C. Hsein Juang:- Seismic geotechnical design of retaining walls should consider the uncertainties not only in soil properties such as friction angle of the backfill but also in earthquake load such as peak ground acceleration (PGA). When the uncertainties are incorporated in the design, the robustness which is a measure of sensitivity of a design to uncertain parameters must be considered and evaluated for obtaining suitable design and corresponding construction cost. This paper presents a response surface-based robust geotechnical design approach for cantilever retaining wall subjected to earthquake load. First, the upper and lower bounds of the design variables were determined through dynamic retaining wall design using Mononobe-Okabe method for possible variations in the uncertain parameters. Then, dynamic finite element analyses were performed on a subset of designs by applying El Centro earthquake motions with varying PGA for computing the maximum wall tip deflection which is considered as the serviceability indicator. A response surface for the wall deflection was developed as a function of uncertain and design variables and validated. Finally, a design optimization was performed considering cost and robustness index as the objectives. Two robustness indices, standard deviation of the response and signal to noise ratio were used in this study and the results were compared. The optimization yielded a set of preferred designs, known as Pareto front, and the knee point concept was used to select the final optimal design.

Dr. S.S Patil and A.A.R.Bagban:- As we know that, retaining wall is one of the most important types of retaining structures. It is extensively used in variety of situations such as highway engineering, railway engineering, bridge engineering and irrigation engineering. Reinforced concrete retaining walls have a vertical or inclined stem cast with base slab. These are considered suitable up to a height of 6m. It resists lateral earth pressure by cantilever action of stem, toe slab and heel slab. The tendency of wall to slide forward due to lateral earth pressure should be investigated and a factor of safety of 1.5 shall be provided against sliding. Cantilever retaining walls are found best up to a height of 6m.For greater heights earth pressure due to retained fill will be higher due to lever arm effect, higher moments are produced at base, which leads to higher section for stability design as well as structural design. This proves to be an uneconomical design. As an alternative to this, one may go for counter fort retaining wall, which demands greater base area as well as steel. As a solution to this difficulty, a new approach that is to minimize effect of forces coming from retained fill , short reinforced concrete members in the form of cantilever steps are cast along the stem on the retaining face. Addition of these steps would counterbalance the locally appearing forces and will result into lesser moment and shear forces along the stem. Also it will reduce the bending action that is pressure below the base. The objectives of the study are To reduce the stresses on the retaining face of the cantilever retaining wall, it is proposed to introduce reinforced concrete steps along the stem. 2) Decide the most economical location of step along length and also along height of wall from number of trials. 3) Decide cross section of the R. C. step as per the stresses due to frictional forces in step. 4) Stability analysis of Cantilever retaining wall with steps for unit width will be done. Check for minimum and maximum stresses will be observed. 5) Cost comparison shall be carried out for these three different alternatives to give most economical retaining wall type.

III. CONCLUSION

From the literature review, author wants to forecast that it is very important to directly examine the effect of RCC Cantilever Retaining wall and figure out the conditions that produce adverse effectiveness methods to automate the human work involved in performing the individual tasks of the construction planning of a reinforced concrete cantilever retaining wall with the help of python programming software. The systems consist of a central database that is interconnected with components that perform the design tasks very economical and analyze and design the modal accurately. Python is a user friendly software & ease of working. Yet even the ability to manage data in an orderly fashion is an improvement over the common present design The optimum design of reinforced concrete cantilever retaining wall can be regarded as rather complicated when compared with other conventional concrete structures. This is due to rigorous checking requirement for overall external stability and internal strength at critical sections practice in which the stages and the software of design are disjointed. Some software has been developed to produce master models and KBE systems. They still depend on programming procedures and a comprehensive understanding of the system structure. The development of such systems for practical use will require to be thoroughly planned. Computers continue to become more powerful and research into the automation methods advances. New software is written and existing software is improved. From an end users perspective off-the-shelf programmed that A BIM already functions somewhat alike to a master model, holding much structural data. The development of software may result in more programmers having capacities for structural design as well as modelling. A change in the professional culture of the construction industry is also possible, all data concerning a structure can be integrated into the model can also extend beyond the planning stage.

This article will provide a good understanding of the origin and development related to the various problems that existed in the context of retaining of soil structure in different region. It is apparent that great deal of work has been done to understand the effects of RCC Cantilever retaining wall. It has been hypothesized that in many cases this structural design can be considered beneficial for multi-purpose residential and / or commercial buildings and other types of civil engineering structures. Numerous evidence is available that demonstrates the effects of RCC Cantilever Retaining Wall on the structural response and highlighted the important contributions. There are various ways to evaluate the effects and each method has its own usefulness and scope of soil retaining and foundation cantilever retaining structure studies. The behaviour of low-rise and high-rise wall structures are different from each other. In the same way the type of retaining wall structure plays a major role in determining the response of the superstructure. From this review article, it is clear that many studies have carried out which give idea.

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