

A STUDY ON EFFECT OF LOADING AND SOIL PARAMETERS IN THE GABION WALL DESIGN

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Abstract : The concept of using gabion facing in reinforced Earth is gathering tremendous growth in the present time as they are gaining considerable attention and providing a valuable alternative to traditional concrete walls gabion faced walls present a low environmental impact. Gabion walls are used for number of reasons among which are no casting, ease of placement, good tolerance for foundation irregularities and outstanding aesthetics. This project is mainly focused on study of effect of loading as well as soil parameters in the design of gabion wall on small scale

Keywords –Gabion walls, Tolerance, Design charts.

1. INTRODUCTION

1.1 GENERAL:

Ground surface is said to be stable so long as it is generally horizontal or it is characterized by gentle slopes. In civil engineering there is a major problem to connect the two different elevations. Whenever we need to have a major vertical discontinuity in the levels of terrain with soil at two different elevations, we need to place a support vertically in the lower level of terrain. By providing a gabion wall as a support we can overcome the effect of one of the major problem in the civil engineering. A gabion wall is a structure which is composed of wire box filled with rocks, stones, concrete

1.2 TYPES OF GABIONS:

Gabion walls are constructed with the help of different materials and they are of different types. Some of them are gabion baskets gabion mattress, gabion sacks, gabion wire mesh and decorative gabion elements. Wire mesh is used to manufacture the cage of gabion and it should possess the design requirements. Gabion baskets are box shaped and different sizes it is made economical with the help of material which are used near the project site. Gabion mattresses are also known as Reno mattresses. Gabion sacks are flexible and porous structures, they are usually used in Hydraulic works and in emergency conditions

1.3 ADVANTAGES OF GABIONS:

The benefits of using gabion walls in place of convention walls are many. Advantages of gabions walls are

Durability: Gabion has a very high resistance to atmospheric corrosion because of the well bonded zinc coating on the wire and their ability to support vegetation growth.

Flexibility: This feature permits the gabion to settle and deform without failure and loss of efficiency. Specifically, when unstable ground and moving water are encountered.

Permeability: It provides automatic and easy drainage which eliminates the need for the installation of drainage pipes.

Strength: Gabions are satisfactory strong that it is capable of resisting flood force, torrential force, and ice and earth pressure.

Economy: It is more economical in terms of both material and labour in comparison with other gabion alternatives.

1.4 APPLICATIONS OF GABIONS:

Common applications of gabions are as follows:

- Retaining structures such as retaining walls, revetment and toe walls to embankments and cuttings.
- Corrosion prevention structures for instance sea walls, river bank defences, canal banks, dams, weirs and for the protection of reservoirs and lakesides.
- Cylindrical metal gabion is used for dams or in foundation construction
- Gabions are also used as a temporary flood walls.
- It is utilized to change the direction of the force of flood water around weak structure

1.5 OBJECTIVES OF WORK:

This project is mainly focused on study of effect of loading as well as soil parameters in design of gabion wall on small scale. Parameters considered for this study are surcharge, breadth of wall, gabion fill density and height. Gabion wall is studied in terms of factor of safety against sliding, eccentricity and bearing pressure. The parameters that are included in the gabion walls design are height of a gabion wall, density of materials, angle of internal friction, soil parameters etc.

Our main work in this project is

- To know about the soil parameters those are effected by applying the load on the gabion wall.
- To study in detail about the design parameters in the gabion walls
- To check the stability of the gabion walls
- To prepare a chart for the construction of gabion wall

2. LITERATURE REVIEW

1.ABHISHEK CHAKOR, studied the use of gabion walls as a load bearing member in the construction of road by considering several factors. The main objective of this paper is to study gabion wall as a retaining structure as well as load bearing member in order to find out if it can exhibit this dual nature and provide structural stability, strength, efficiency and help in reducing the overall cost.

OUTCOMES:-

- They have been widely used as a flood and erosion control structures on the banks of the rivers in low lying areas.
- They are also used to provide lateral support to the soil in hilly areas.

2.AMATO G et al, has studied the capacity of gabions to blend in to natural landscape, suggesting that they could be used as a safety barrier for low-volume road in scenic environments. To assess the potential use as a roadside barrier, the optimal gabion unit size and mass were investigated using multi-body analysis.

OUTCOMES:-

- The test resulted in a failure due to roll over of vehicles and tearing of gabion mesh yielding a large working width.

3.ANCYAND MERCY has done a comparative study of reinforced earth retaining walls and gabion walls as more economical solution as well as environmental friendly as compared to retaining walls. In this study for the purpose of comparative study, two sites with soils of different properties were selected and the details of soil to be retained were taken.

OUTCOMES:-

- Gabion walls are found to be very economical and eco- friendly with the advancement of technology for the last few decades

4.BARAN TOPAK et al, has done a study on gabion wall and their use. The paper focuses on application of gabion wall at various places to serve their purpose.

OUTCOMES:-

- Advantages of gabions like flexibility, permeability, eco- friendly, economical and aesthetic look.
- The production of flexible wires using today's technology can be used for 30-100 years.

5. T. PEERDAWOOD AND YOUSIF MAWLOOD, has done research on analytical study of external stability factors on common gabion walls. The stability involves checking, sliding, overturning, and bearing capacity of the gabion walls

OUTCOMES:-

- Investigation of mechanical behaviour of soil confined with geo textiles
- Analysis on failed case of soil gabion wall by numerical method

6. C. SCOTT HARDAWAY JR, has studied the Durability of Gabions Used for Marine Structures

OUTCOMES:-

Durability of gabion construction depends on the following environmental factors. They are

- water salinity
- Environmental conditions
- wave action

7. ESRAURAY AND OZCANTAN, In this study the design criteria of gabion retaining wall was investigated by using Taguchi method. Different Taguchi design tables were formed by these using parameters.

OUTCOMES:-

- The evolution of deformation observed suggested that the interlocking design exhibits better structural integrity than the conventional box gabion based wall in resisting lateral movement

8 .FERRIOLO, this paper mainly focused on the applications of flexible gabions in several works such as retaining walls, noise barriers, temporary flood walls, silt filtration from runoff.

OUTCOMES:-

- The erosion is controlled by gabion structure due to its main characteristics of high resisting weight and high permeability.

3. DESIGN WORK

3.1 GENERAL:

The main aim of the project is to study the effect of loading as well as soil parameters in the design of gabion wall and there by evaluating the factor of safety against sliding, check for eccentricity, check for bearing pressure is done. Finally, charts are developed to obtain the values of surcharge and density of gabion fill materials for the given heights. With the help of those values, factor of safety can also be directly obtained.

3.2 DESIGN STEPS:

3.2.1 PARAMETERS OF DESIGN:

Wall height = H

Surcharge = q

Backfill slope angle = i

Angle of friction between wall and soil = ϕ

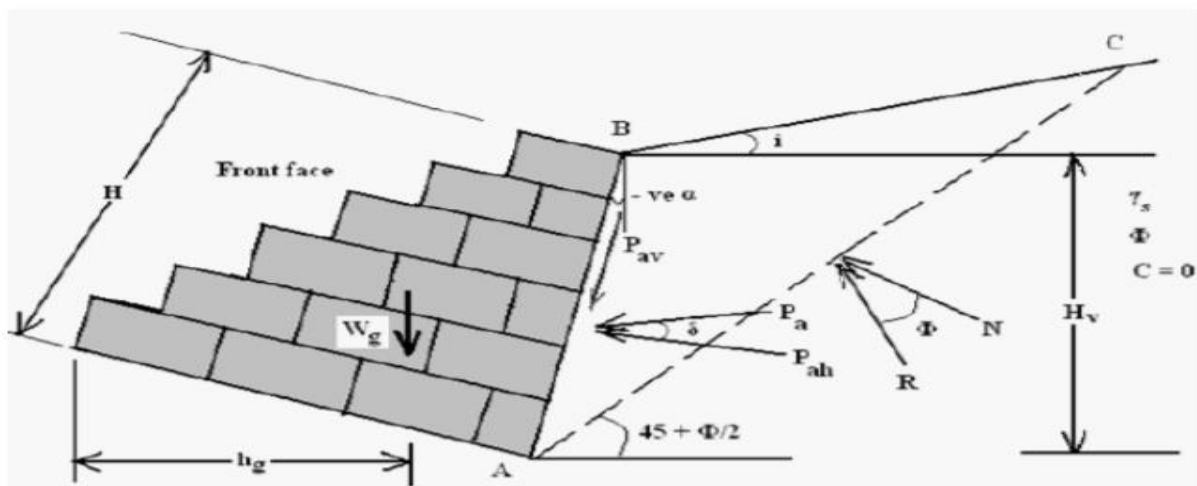
Wall inclination with vertical = α

Soil friction angle = δ

Soil density = s

Gabion fill density = g

Soil bearing pressure = q allowable



3.2.2 STEPS INCLUDED IN THE DESIGN:

1) Lateral Earth pressure on retaining wall:

Total active thrust on the wall , $Pa=K_a(h^2/2+qh)$

Horizontal component, $P_h=P_a \cos(\phi-\alpha)$

$$K_a = \frac{\cos^2(\phi-\alpha)}{\cos^2 \alpha * \cos(\alpha + \delta) \left[1 + \frac{\sin(\phi+\delta) \sin(\phi-i)}{\cos(\delta+\alpha) \cos(i-\alpha)} \right]^2}$$

According to coulombs derivation, co-efficient of active earth pressure

When surcharge is there and wall is inclined to an angle α , the vertical distance of the point of application of the resultant normal force(P_a) from toe = h_y

$$h_y = H/3 * \frac{[H + \frac{3q}{\gamma_s}]}{[H + \frac{2q}{\gamma_s}]} - L \sin \alpha$$

2) Calculation of weight of gabion (W_{gabion}):

$$W(\text{gabion}) = g * \text{volume of wall per unit length}$$

3) Calculate the horizontal distance of point of application of the weight of gabion wall from toe (h_g)

$$h_g = (a * X) / A$$

4) Calculation of factor of safety against sliding

$$\text{Driving force } F_d = P_h - (W_{gabion} * \sin \alpha)$$

$$\text{Resisting force } F_r = (W_{gabion} * \cos \alpha + P_a \sin \delta) * \tan \phi$$

$$\text{Factor of safety (FOS)} = F_r / F_d > 1.5 \text{ (safe)}$$

5) Calculation of factor of safety against overturning

$$\text{Overturning moment } M_o = P_a * h_y$$

$$\text{Resisting moment } M_r = W_{gabion} * h_g$$

$$\text{Factor of safety (FOS)} = M_r / M_o > 2 \text{ (safe)}$$

6) Check for eccentricity (e):

$$e = M_o / W_{gabion}$$

if $-L/6 < e < +L/6$ then safe

7) Check against bearing pressure

$$P_b = \frac{W_{gabion}}{(B - 2e)} < q_{allowable} \text{ (safe)}$$

4. PARAMETRIC STUDY

4.1 GENERAL:

This chapter deals with the design parameters in the construction of gabion wall. There are some constant and varying parameters considered in our study of gabion wall design. A brief detail is mentioned in this chapter about the varying parameters and their limits considered for our study and preparation of charts.

4.2 CONSTANT PARAMETERS:

Density of soil = s

Back fill slope angle = i

Angle of friction between wall and soil = ϕ

Soil friction angle = δ

Soil bearing pressure = $q_{allowable}$

Wall inclination with vertical = α

4.3 VARYING PARAMETERS:

Wall height = H

Surcharge = q

Density of gabion fill = g

Breadth of gabion wall = b

4.4 PARAMETERS STUDIED:

Various parameters studied and their limits considered for our study are mentioned in this topic.

| PARAMETER STUDIED | RANGES OF PARAMETER |
|---|----------------------------------|
| HEIGHT in m | 1,2,3,4,5,6,7,8,9,10 |
| SURCHARGE in KN/m ² | 0,10,20 |
| BERADTH OF GABION WALL in m | 0.5, 1, 1.5 |
| GABION FILL DESNSITY in KN/m ³ | 15,16,17,18,19,20,21,22,23,24,25 |

Table 4.4: Ranges of parameters

4.5 RECOMMENDED VALUES:

- Designs are made for small scale model
- As per IRC SP 102:2014 clause 3.1 , ϕ should be greater than 25°
- As per BS 8002-1994 $i = 5-10^\circ$
- Assumed $\alpha = 0^\circ$
- Design is made for

H= 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 m
 q = 0, 10, 20 KN/m²
 b = 0.5, 1, 1.5 m
 g = 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 KN/m³

- For dense soils s = 18 KN/m³

5. DESIGN

5.1 GENERAL :

The values of eccentricity, factor of safety against sliding, bearing pressure are obtained according the selection of value of height. Heights were considered from 1-10m. For the required value of height, we can obtain the values of eccentricity, factor of safety against sliding, bearing pressure by using the design charts

5.2 DESIGN EXAMPLE:

Consider a factor of safety against sliding in between 3.5 – 3.6
 In case of surcharge, q=10 KN/m² and width of wall, b = 1m
 Draw a horizontal line on chart at factors of safety of values of 3.5, 3.6
 Find the points in between them
 Various values corresponding to height and density of gabion fill are obtained.
 In this case, available options are

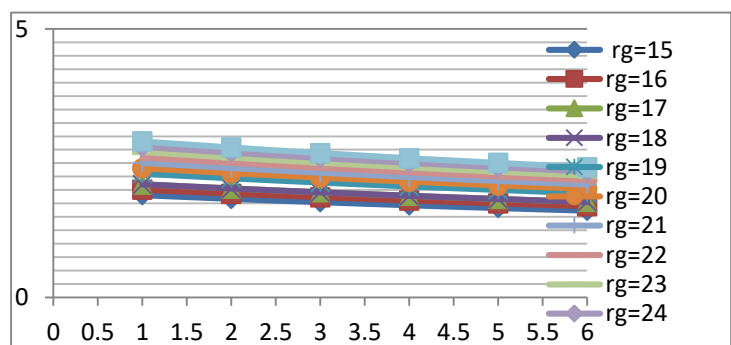
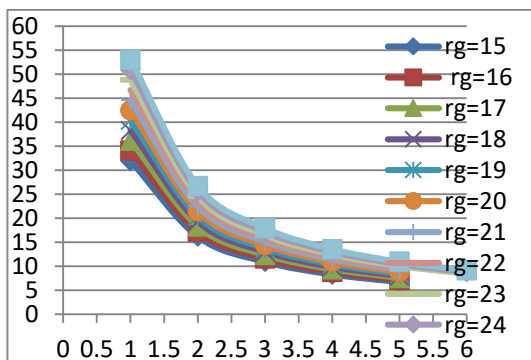
- Height, h = 3m and density of gabion fill = 17 KN/m³
- Height, h = 3m and density of gabion fill = 18 KN/m³
- Height, h = 4m and density of gabion fill = 19 KN/m³
- Height, h = 7m and density of gabion fill = 20 KN/m³
- Height, h = 8m and density of gabion fill = 21 KN/m³
- Height, h = 9m and density of gabion fill = 22 KN/m³

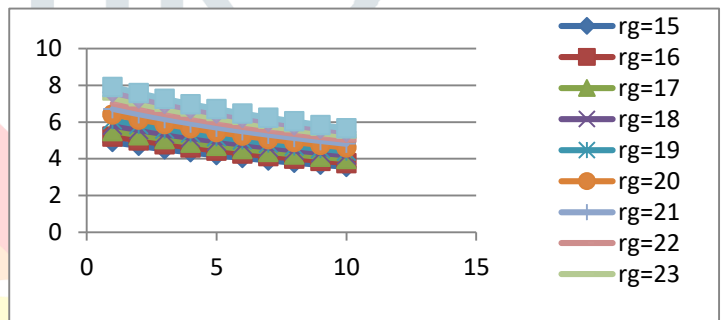
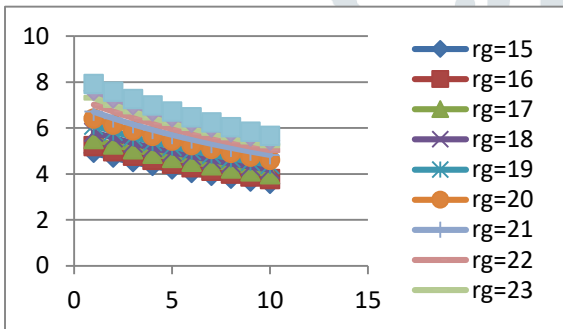
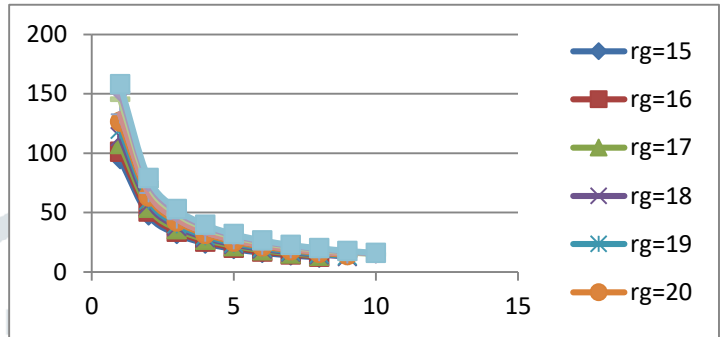
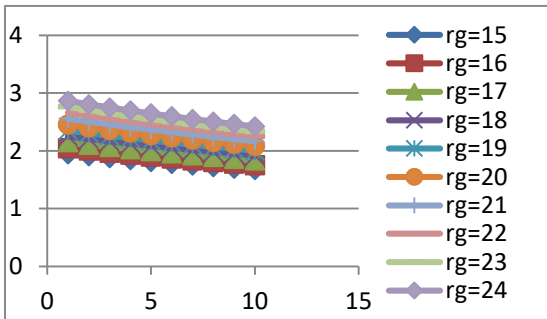
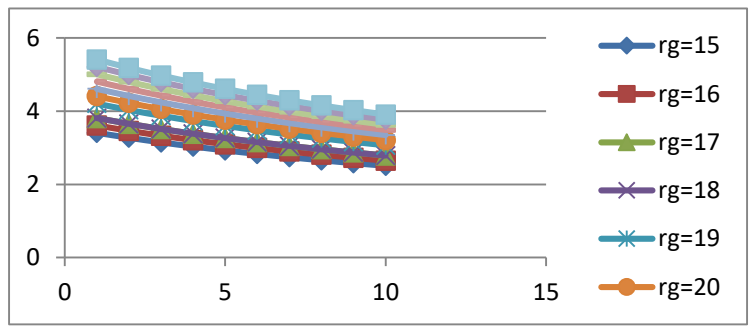
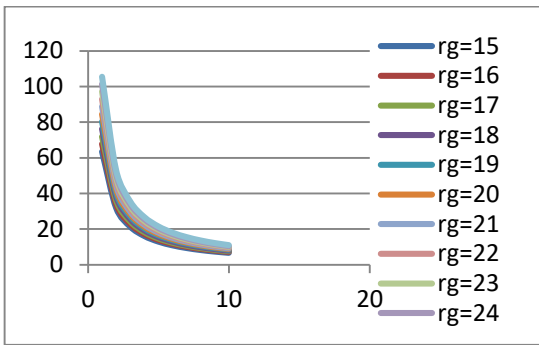
6. RESULTS AND DISCUSSIONS

6.1 GENERAL:

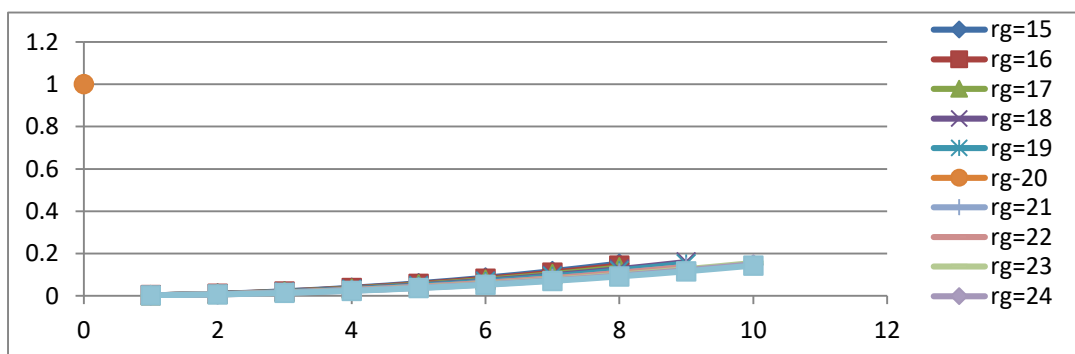
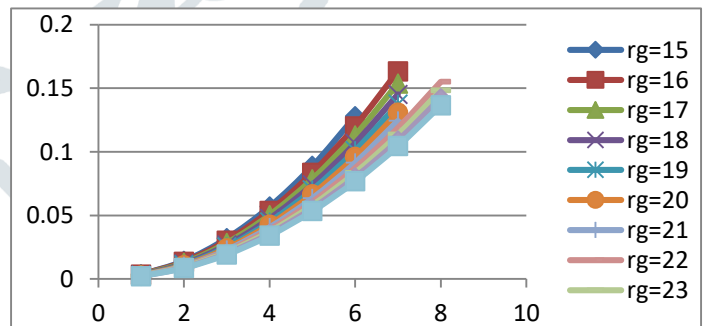
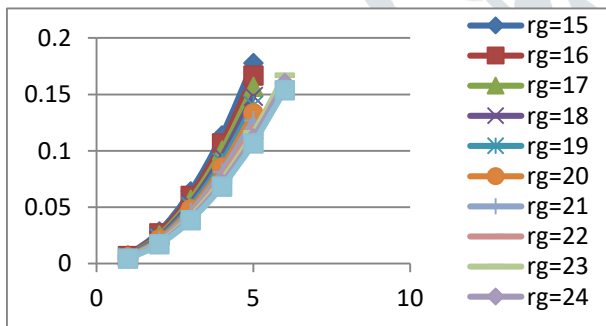
Designing of wall with different values of various varying parameters is done to prepare a design chart for the construction of gabion wall. In this chapter, results of all the studies are explained in detail in the form of graphs.

6.2 STUDY WITH RESPECT TO FACTOR OF SAFETY AGAINST SLIDING:

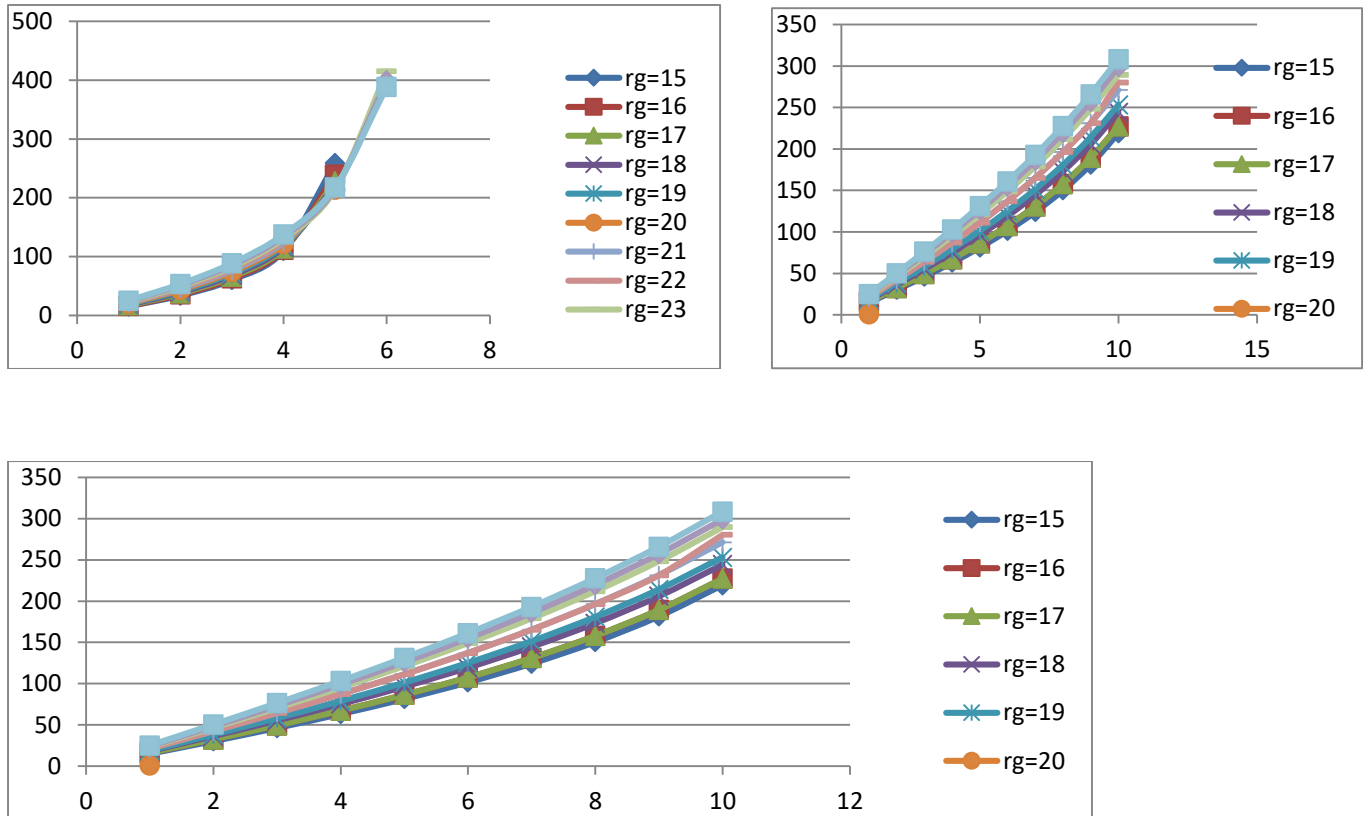




6.3 STUDY WITH RESPECT TO ECCENTRICITY:



6.4 STUDY WITH RESPECT TO BEARING PRESSURE:



7. CONCLUSIONS:

The following conclusions are obtained with respect to factor of safety against sliding, eccentricity and bearing pressure at given values of surcharge and width of wall

- Factor of safety against sliding increases by 10-15% with increase in density of gabion fill from 15-25 KN/m³ and decreases by 15-30% with increase in height of wall from 1-10 m at given values of surcharge and width of wall.
- With increase in surcharge from 0-20 KN/m² and width of wall from 0-1.5m, FOS against sliding decreases.
- For constant value of width and increase in surcharge from 0-20 KN/m², FOS decreases and become unsafe beyond 20KN/m².
- For given values of surcharge and width of wall, eccentricity decreases from 0.82 to 0.0042 with increase in density of gabion fill from 15-25KN/m³ and increases by 0-1% with increase in height of wall from 1-10m.
- With increase in width of wall from 0.5-1.5m under constant load, eccentricity decreases.
- For given values of surcharge and width of wall, bearing pressure increases by 1-10% with increase in height from 1-10m and density of gabion fill from 15-25 KN/m³.
- With increase in width of wall from 0.5-1.5m under constant load, bearing pressure does not have major change.
- With increase in surcharge from 0-20 KN/m² and width of wall from 0.5-1.5m, eccentricity and bearing pressure becomes unsafe.

REFERENCES:

1. Ambrose J.(1991).“Simplified Design of Masonry Structures”. New York: John Wiley and Sons, Inc pp.70–75.ISBN0471179884.
2. Collin J.G.(2001).“Lessons Learned from a Segmental Retaining Wall Failure, Geo-textiles and Geo-membranes”,19,445–454
3. D.G.Lin, Y.H.Lin, and F.C.Yu, “Deformation analysis of gabion structures”, in INTERPRAEVENT 2010,Taipei, Taiwan,2010,pp.512-526.
4. Ferriolo F, Vicari , M.Kulkarni, T.P. and Gharpure A.D.(1997):“Landslide Road Protection and River Training Works with Gabion Structures, Proceedings of Geo-synthetics”Asia’97, Bangalore, India, Pp.11.13-11.20.