TUJNAS
Thamar University Journal of Natural & Applied Sciences ISSN: 2073-0764
2010 A(**3**) 77-83 © 2010 Thamar University

Effects of Some Gate Lip Shapes on Downpull Force in Dam Tunnels

Thamir M. Ahmed

Faculty of Engineering / Thamar University, thamer6085@yahoo.com

ABSTRACT

The gate which controls the flow through the dam tunnel is termed as lift gate. Such gates are subjected to the hydrostatic and hydrodynamics forces, since the flow passes over and beneath the gate and produces pressures at the top and bottom of the gate surfaces. The differences between these two pressure forces are termed as downpull force. The evaluation of this force is very important due to its effects on closure of the gate, its positive and / or negative values.

The estimation of downpull force requires the determination of top and bottom pressure coefficients for wide range of discharges, gate openings, velocity, and pressure distribution in many locations .For the present research these measurements have prepared for different types of gate lip shapes along with laboratory hydraulic tunnel model which have been used. Various flow conditions and gate openings have been examined .The results concluded from the measurements and analysis tend to confirm the effects of the gate lip shapes on the values of downpull force, which in case of its negative value will prevent the gate to close and make some failures and damages.

INTRODUCTION

Lift gates are among the common types of gates used for regulating the flow of water through the large conduits and outlets. One type of such gates is the tunnel gates which operate through a shaft located at a distance from the inlet of the tunnel and exposed to two main forces. The first one results from the flow passing over the gate top surface while the second one produced from flow issuing beneath the bottom gate surface.

The difference between these two forces induces an unbalanced force which may be in the downward direction, called a hydraulic downpull force, or in the upward direction termed negative downpull or uplift force. Since the magnitude of the downpull force affects the design of the gate –hoisting equipment, about which hydraulic engineers and designers greatly predict.

The evaluation of hydraulic downpull forces for various relevant parameters has been studied by many researchers .Cox et al [1] have developed a dimensionless relationship among many hydraulic variables for estimating the stability of the gate .Naudascher et al [2] have conducted experiments on a hydraulic air model to formulate the effects of many parameters on high head leaf gates . The formulation can be expressed as follows:

$$F_d = (K_t - K_b).B.d.\rho.V_j^{\,2} / 2 \qquad (1)$$

$$K_t = (H_t - Y_s)/(V_j^{\,2}/2g) \qquad (2)$$

$$K_b = (1/B.d)\iint [(H_i - Y_s)/(V_j^{\,2}/2g)]dB.dX \qquad (3)$$

Where:
Fd: downpull force,
B: gate width,
d: gate thickness,
ρ: water mass density,
Vj: velocity at the vena contracta beneath the gate,
Ht: piezometric head on gate on gate top surface,
Hi: piezometric head at a point on gate bottom surface ,and
Ys: piezometric head in the contracted jet.
The downpull force can also be expressed as follows [3]:

$$F_d = F_t - F_b \qquad (4)$$

Or

$$F_d / 0.5\rho A V_j^{\,2} = F_t / 0.5\rho A V_j^{\,2} - F_b / 0.5\rho A V_j^{\,2} \qquad (5)$$

Where:
Ft, Fb: forces on the top and bottom gate respectively ,and
A : appropriate cross sectional area of the gate.
The downpull force can also be expressed in terms of upstream head as shown below[8]:

$$K_d = F_d / \gamma H A \qquad (6)$$

Where:
γ :weight density of water, and
H: operating head, m .

Sagar et al [5] have reported that the numerous geometrical features of the gate influencing the downpull force can be formulated as follows :

$$Fd = f(H, Y/Y_o, e/d, \theta, b_1/b_2, d'/d, d/Y_o, r/d) \qquad (7)$$

Where:
H :operating head,
Y/Yo :opening ratio,
(e/d,θ) : gate bottom geometry,
b1/b2 :gap width ratio,
d′/d :thickness ratio of the skin plate to the top assembly,
d/Yo :gate thickness ratio ,and
r/d :curvature radius on upstream bottom portion of the gate.

The relation between the maximum downpull force and the operating head has been formulated by Poondi research station [4] as follows:

$$Fd = 7.3H^{0.427} \qquad (8)$$

Uppal and paul [7] indicate that for gate with bottom concave curvature , the maximum downpull can be expressed as follows :

$$Fd = 0.0418H^{1.625} \qquad (9)$$

In this research the downpull force has been evaluated by using the data obtained from experiments conducted on systematic hydraulic model with many types of gate lip shapes [6] ,and compared the results with those obtained from previous works.

RESULTS AND DISCUSSION

The experiments were achieved by the run of hydraulic model included all measurements required for evaluating the downpull force , especially the top and bottom piezometric head distribution which was necessary for determination the top and bottom pressure coefficients (Kt and Kb) .

Fig.(1) shows the different types of gate shapes used in the current research . Figures (2 to 5) show the variation of (Kt , Kb) and downpull force coefficient (Kd) for various gate shapes and openings.

It can be seen from Figure (2) that the (Kt) and (Kb) are both high and caused the downpull force coefficient (Kd) to be negative in values for gate openings (Y/Yo=0.6,0.7,0.8 and 0.9) , this may be because the gate shape is with the lip extension .Figure (3) indicates that for gate with curvature upstream bottom (r/d=1),the (Kt) and (Kb) differ much in values and tend the values of (Kd) to be positive for all gate openings except (Y/Yo=0.8 and Y/Yo=0.9) .Figure (4) shows that for gate lip shape inclined with θ=35º,the values of (Kd) are positive for all gate openings. Figure (5) indicates that for gate lip shape inclined with θ=45º ,the values of (Kd) are positive for the gate openings (Y/Yo=0.2,Y/Yo=0.4,and Y/Yo=0.6),then seem to be negative for the remaining gate openings ratios.

CONCLUSIONS

The comparisons between the gate lip shapes considered in the present research indicate that the use of gate lip shape with θ=35º has kept the (Kd) values as minimum and reduced the effects of negative downpull.

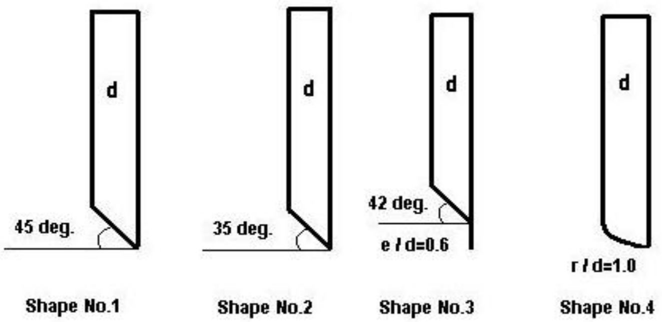

Figure (1): Lip gate shapes adopted in the analysis

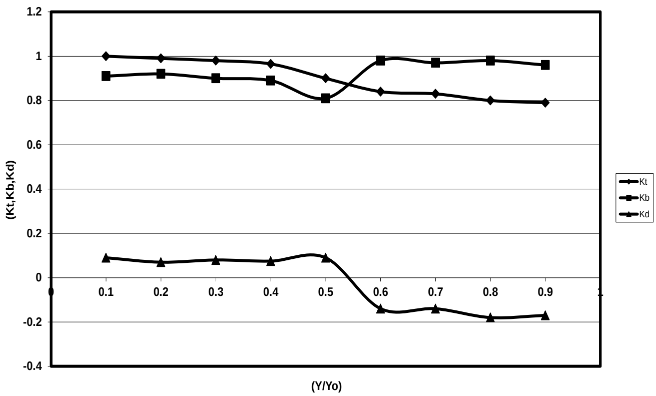

Figure (2):Variation of Pressure coefficients With Gate Openings.(Shape No.3)

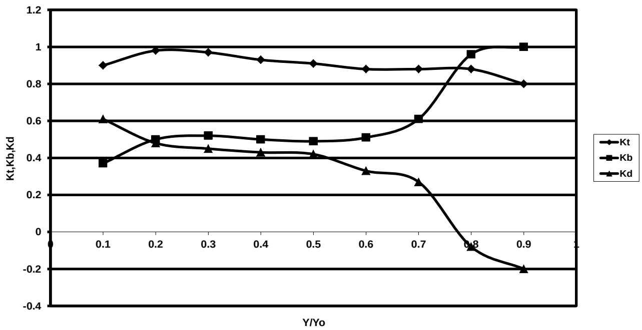

Figure (3):Variation of Pressure coefficients With Gate Openings.(Shape No.4)

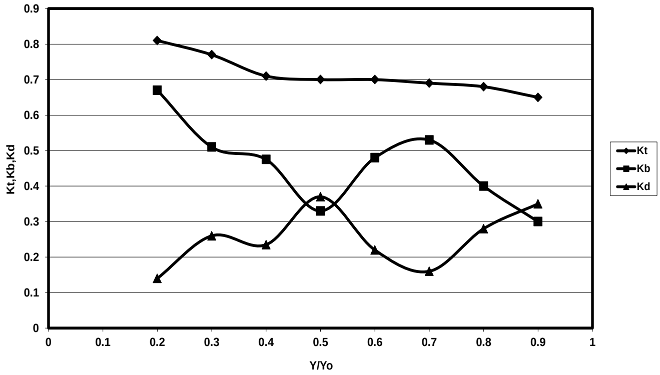

Figure (4): Variation of Pressure Coefficients with Gate Openings.(Shape No.2)

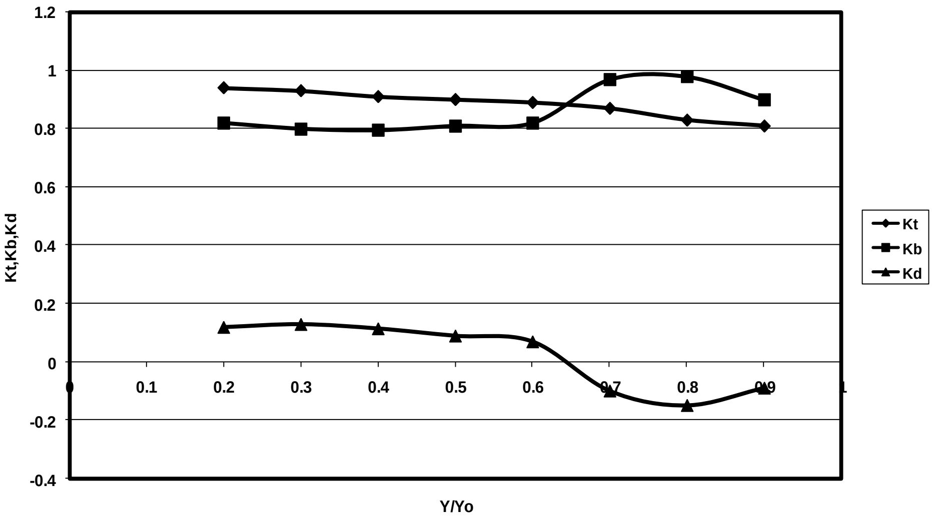

Figure (5):Variation of Pressure coefficients With Gate Openings.(Shape No.1)

REFERENCES

[1] Cox Robert G.and Ellis B.Pickket and W.p.Simmons,May (1960), "Hydraulic Downpull on High Head Gates ",Asce Discussion HY5.

[2] Naudascher,E.,Helmut E.Kobus .and Ragam P.Rao, (1964), "Hydrodynamics Analysis For High Head Leaf Gates ", ASCE Vol.90,No.HY3,.

[3] Sagar,B.T.A., (1977),"Downpull In High –Head Gates Installation", Water Power &Dam Construction.

[4] Sagar,B.T.A., March (1978),"Prediction of gate shaft pressure in tunnel Gates ", Water Power &Dam Construction.

[5] Sagar ,B.T.A. and J.P. Tullis, December (1979) ,"Downpull In Vertical Lift Gates ", Water Power &Dam Construction.

[6] Ahmed,Th.M., Ph.D. thesis ,March (2000),Effects of Gate Lip Shapes On The Downpull Force In Tunnel Gates" .

[7] Uppal,H.L.and Paul ,T.C., October (1964)," Design of For High Head Reservoir Outlets", Indian Journal of Power and River Valley Development.

[8] US Bureau of Reclamation, (1966)," Hydraulic Downpull Force on large Gates ",Research Report No.4.

تأثير بعض أشكال أسفل البوابات
على قوى السحب في أنفاق السدود

ثامر محمد أحمد

كلية الهندسة - جامعة ذمار – ذمار - اليمن

ملخص

البوابة التي تسيطر على حركة الجريان في نفق السد يطلق عليها بوابة الرفع. هذا النوع من البوابات يتعرض الى قوى ستاتيكية وأخرى هيدروديناميكية نظرا لحركة الجريان من فوقها ومن تحتها ، وهذه الحركة تسبب حدوث ضغوط فوق البوابة وتحتها . يُدعى الفرق بين القوتين الناجمتين عن هذه الضغوط قوى السحب ، كما إن دراسة هذه القوى مهمة جدا بالنسبة لتأثيرها على إغلاق البوابات .

ويتطلب يجاد قيمة قوى السحب إيجاد قيم معاملات الضغوط في السطح العلوي والسطح السفلي للبوابة خلال مدى واسع من قيم التصريف وسرعة الجريان وتوزيع الضغوط مقابل قيم مختلفة لفتحات البوابة . في هذا البحث تم اختبار مجموعة من أشكال أسفل البوابة خلال قيم مختلفة من الجريان وفتحات البوابة في نموذج هيدروليكي لنفق السد . أكد تحليل نتائج القياسات على وجود تأثير لشكل أسفل البوابة على قيم قوى السحب ، خصوصا وأن القيم السالبة ستؤدي الى منع إغلاق البوابة حيث ستترتب عليه مخاطر وفشل في السد.