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A STUDY ON RUBBER CUSHION DAM AND IT'S USING FOR COAST AND PORT ENGINEERING

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ABSTRACT

Rubber cushion dams are inflatable and deflatable hydraulic structures. Thousands of rubber dams have been installed worldwide for various purposes: irrigation, water supply, power generation, tidal barrier, flood control, environmental improvement, and recreation.Rubber dams have been used for the past ۴۰ years in river and coastal engineering applications, in all of the world and overseas. An inflatable rubber dam is basically an envelope formed from a fabric-reinforced rubber membrane which is anchored to a concrete foundation The membrane that forms the rubber dam typically is constructed with multiple layers of reinforcement fabrics such as nylon or even rubber.

Despite the increasing interest for rubber dams, little information is available on their hydraulic performances. The overflow characteristics of inflated rubber dams are re-investigated. In this article the concept design method of rubber cushion dam for control the flood and surface water have been showed and discuss for using of this technology for coast engineering (especially near the bank and river side).The advantage of this research satisfied the physical characters of Iranian ports and many other part of Persian Gulf coast.

Introduction

Rubber dams are long tubular-shaped fabrics placed across channels, streams and weir crest to raise the upstream water level when inflated (Fig. ۱). In open channels, they are commonly used to raise water levels, to increase water storage and to prevent chemical dispersion (Table ۱). The interest in inflatable dams is increasing because of the ease of placement. Such structures can be installed during later development stages. The membrane is usually deflated for large overflows. It is however common practice to allow small spillages over the inflated dam. During overflows, vibrations might result from fluid-structure interactions (e.g. OGIHARA and MARAMATSU ۱۹۸۵, WU and PLAUT ۱۹۹۶), and the instabilities might damage and destroy the rubber membrane. Several failures were experienced including in Australia. In practice, a deflector (i.e. fin) is installed on the downstream face of the rubber dam to project the cushion away from themembrane, hence preventing rubber membrane vibrations (Fig. ۲). Little attention has

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been paid on the overflow hydraulics. ANWAR (۱۹۶۷) investigated experimentally small overflow. Other studies (e.g. SHEPHERD et al. ۱۹۶۹, BINNIE et al. ۱۹۷۳) discussed the fluid-structure interactions of inflated rubber dams. In the present paper, the characteristics of rubber dam overflow are re-investigated. New analytical calculations of cushion trajectory are presented and the results are compared with laboratory experiments. New guidelines for the optimum design of rubber dam deflector are discussed. Rubber dam supplies :

-Oil spill response equipments , oil absorbent boom and sorbet , oil trawl,

-Air filling rubber dam and water filling

-Inclined rubber dam & pillow Like rubber dam

-Float rubber boom& float storage rubber tank

-High pressure cleaner, hose reels, inflating rubber boom,

-Oil dispersant sprayer, portable oil rubber PVC tank

- Fence boom, rock cleaner, rope mop skimmer, engineering rubber boom

RUBBER CUSHION DAM

The membrane that forms the rubber dam typically is constructed with multiple layers of reinforcement fabrics such as nylon or even rubber. The construction shown on the Fig ۲ has three layers of nylon fabric and external cover of rubber and would typically be used for a rubber dam over ۲ m high in fresh water with a high level of debris. Membranes are designed and constructed to meet the individual requirements of each installation. The correct selection of construction materials and correct manufacturing techniques maximizes the reliability and service life of the rubber dam. Membranes can be constructed using one or more different rubber compounds depending on the application. Rubber provides superior resistance to sunlight, ozone and temperature. Neoprene can be used when extra abrasion resistance is required. Natural rubber tends to increase water tightness, air tightness and flexibility. The outer layer thickness is designed to provide extended durability, improve puncture resistance and prevent deterioration of the fabric reinforcement.

Cushion equation and inflatable bag

Considering a fully-inflated rubber dam, the downstream face of the dam follows closely the shape of a circular cylinder as observed by ANWAR (۱۹۶۷). For the sake of simplicity, we shall consider an idealised rubber dam shape Downstream of the crest, the overflowing cushion adheres to the weir face because the convex wall curvature imposes a pressure field modification within the cushion inducing a suction pressure. The resulting Coanda effect acts on the wall surface in a direction normal to the flow direction. At the crest, critical flow conditions occur. Downstream of the crest, the flow depth and velocity derive from the continuity and motion equations. Assuming an ideal-fluid flow, it yields :

$$F = \sqrt{F_{crest}^2 + 2 * (1 - \cos\phi)} \qquad (1)$$

$$\frac{d}{R} = \left(\frac{d_{crest}}{R}\right)^{3/2} * \frac{C_D}{k^{3/2}} * \frac{1}{F} \qquad (2)$$

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where d is the flow depth, V is the velocity, F = V/ g*R, φ is the angular position, Fcrest = Vcrest/ g*R, CD is the discharge coefficient, H۱ is the upstream total head, D is the dam height, dcrest is the flow depth at the crest, R is the radius of curvature and k = dcrest/dc accounts for the streamline curvature and non-uniform distributions of pressure and velocity at the crest (Fig. ۲). At the surface of the rubber dam, the wall pressure may be deduced from the motion equation in the radial direction. At any position φ, the dimensionless pressure distribution at the wall equals :

$$\frac{P_{atm} - P_s}{\rho_w * g * R} = \frac{d}{R} * \left(F^2 - \cos\phi * \left(1 + \frac{d}{2 * R}\right)\right) \quad (3)$$

where Ps is the absolute pressure at the wall, Patm is the atmospheric pressure, ρw is the water density. Equation (۳) predicts an increasing suction pressure (Patm - Ps) down the rubber membrane as the flow is accelerated. The chushion adherence on the wall might lead to flow instability at the base of the chushion (i.e. next to the separation position), pressure fluctuations on the downstream face of the dam and vibrations of the flexible membrane. Chushion adherence instabilities may be eliminated by deflecting the chushion off the rubber wall (Fig. ۳). At take-off the flow properties (do, Vo, θo) are deduced from the Bernoulli and continuity equations, neglecting energy losses and assuming that the effects of the developing boundary layer are small (i.e. Eq. (۱) and (۲)). Usually the deflected chushion angle θo at take-off is smaller than the deflector angle θ, and it may be estimated in first approximation as :

$$\frac{\theta_o}{\theta} = \sqrt{\tanh\left(\frac{h}{d_o * \theta}\right)} \quad (4)$$

where h is the deflector height measured normal to the wall
and do is the cushion thickness at take-off (Fig. ۳).The trajectory equations of a ventilated cushion are :

$$\frac{x}{R} = \frac{V_o}{\sqrt{g * R}} * \cos(\phi_{def} - \theta_o) * \sqrt{\frac{g * t^2}{R}} + \frac{x_o}{R} \quad (5)$$

$$\frac{y}{R} = -\frac{1}{2} * \frac{g * t^2}{R} - \frac{V_o}{\sqrt{g * R}} * \sin(\phi_{def} - \theta_o) * \sqrt{\frac{g * t^2}{R}} + \frac{y_o}{R} \quad (6)$$

where x is the horizontal direction, y is the vertical direction positive upwards, t is the time, xo and yo are the co-ordinates of the deflector edge, φdef is the angular position of the deflector.Equations (۱) to (۶) may be combined to predict the cushion trajectory from the crest down to the cushion impact.

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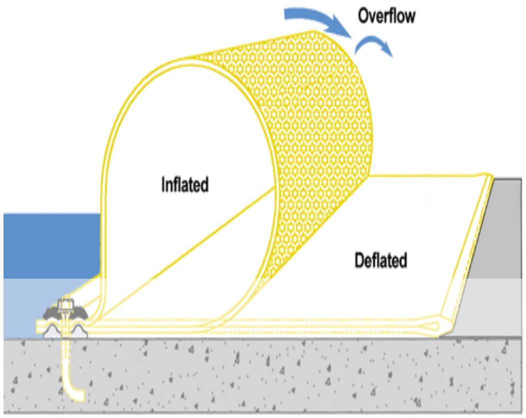

Fig ۱)View of Rubber dams and inflatable structure

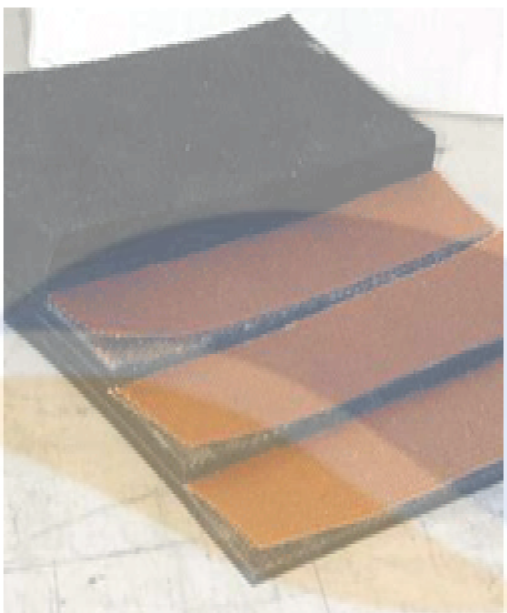

Fig ۲)layers of rubber dam

Table ۱) Rubber dam installed in Australia

Year (1)	Site (2)	Characteristics (3)	Manufacturer (4)	Remarks (5)
1965	Koomboolooomba dam, QLD	$L = 1 \times 60$ m, $D = 1.22$ & 1.5 m, $H_{infl} = 0.91$ m	Fabridam-Firestone	No deflector. Water filled. Placed on ogee crest. Design overflow : 2.4 m^2/s (inflated), 35 m^2/s (deflated).
1967	Proston weir, QLD	$L = 1 \times 51$ m, $D = 1.5$ m, $H_{infl} = 1.4$ m	Fabridam-Firestone	No deflector. water filled
1983	Val Bird weir, North QLD	$L = 2 \times 82$ m, $D = 1.9$ m, $H_{infl} = 0.5$ m	Fabridam-Firestone	Water filled.
1996	Lyell dam, NSW	$L = 2 \times 40$ m, $D = 3.5$ m, $H_{infl} = 1.4$ m	Bridgestone	With deflector. Air filled
1997	Dumbleton weir, Central QLD	$L = 2 \times 75$ m, $D = 2$ m, $H_{infl} = 0.7$ m	Queensland Rubber Co.	With deflector. Air filled.

SUMMARY AND CONCLUSION

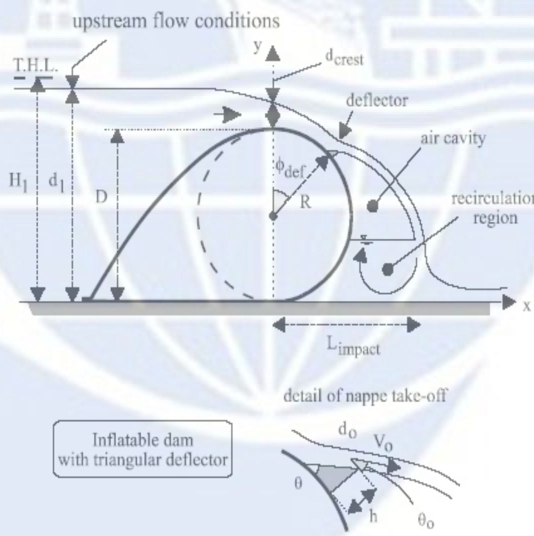

Fig ۳: Characteristics of rubber Dam

Fig ۴: Rubber Dam View on River

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Rubber dams have been used for the past ۴۰ years in river and coastal engineering applications, in all of the world and overseas. An inflatable rubber dam is basically an envelope formed from a fabric-reinforced rubber membrane which is anchored to a concrete foundation The membrane that forms the rubber dam typically is constructed with multiple layers of reinforcement fabrics such as nylon or even rubber. Rubber dams are inflatable and deflatable hydraulic structures. Furthermore, rubber dams have been used in cold areas where the temperature is as low as – ۴۰°C. The simplicity and flexibility of the rubber dam structure and its proven reliability are key considerations in its wide scope of applications. The membrane that forms the rubber dam typically is constructed with multiple layers of reinforcement fabrics such as nylon or even rubber.
The advantage of this research satisfied the physical characters of Iranian ports and many other part of Persian Gulf coast.

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REFERENCES

[۱]ANWAR, H.O. (۱۹۶۷). “Inflatable dams.” *Jl of Hyd. Div.*,ASCE, Vol. ۹۳, No. HY۳, pp. ۹۹-۱۱۹.
[۲]BINNIE, G.M., THOMAS, A.R., and GWYTHER, J.R.(۱۹۷۳). “Inflatable Weir used during Construction of Mangla
[۳]Dam.” *Proc. Instn. Civ. Eng.*, Part ۱, Vol. ۵۴, Nov., pp. ۶۲۵-۶۳۹. Discussion : ۱۹۷۴, Part ۱, Vol. ۵۶, pp. ۱۸۹-۱۹۴.
[۴]CHANSON, H. (۱۹۹۶). “Some Hydraulic Aspects duringOverflow above Inflatable Flexible Membrane Dam.” *Report*
CH ۴۷/۹۶, Dept. of Civil Engineering, University of Queensland, Australia, May,
[۵]CHANSON, H., and MONTES, J.S. (۱۹۹۷). “Overflow Characteristics of Cylindrical Weirs.” *Research Report No.*
[۶]SARPKAYA, T. (۱۹۶۸). “The Deflection of Plane Turbulent Jets by Convex Walls.” *US Govt Research Report No. AD ۶۷۳۳۴۹*, Naval Postgraduate School, Monterey CA,USA
[۷]SHEPHERD, E.M., McKAY, F.A., and HODGENS, V.T.(۱۹۶۹). “The Fabridam Extension on Koombooloomba Dam of the Tully Falls Hydro-Electric Power Project.” *Jl Instn. Of Eng., Australia*, Vol. ۴۱, pp. ۱-۷.
[۸]WU, P.H., and PLAUT, R.H. (۱۹۹۶). “Analysis of the Vibrations of Inflatable Dams Under Overflow Conditions.” *Thin-Walled Structures*, Vol. ۲۶, No. ۴, pp. ۲۴۱-۲۵۹.

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