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OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

B.E. Degree – Civil Engineering & Environmental Engineering

EH 405 – Engineering Hydraulics II

SUMMER EXAMINATIONS 2005

Examiners: Professor K.J. Beven
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Mr. M. Joyce

Time allowed: Two hours
Attempt questions in multiples of 10 marks to a total of 50 marks

1. (a) Describe a field method for the assessment of the internal condition of a working water supply pipeline, where it is suspected that the effective diameter has been reduced, and the pipe roughness has been increased, by encrustation. Illustrate your answer by appropriate sketches. *[5 marks]*

(b) How may such problems be remedied in practice, and what operational constraints might be expected to apply? *[5 marks]*

2. (a) Listing the three forms of energy head present at a point in a pipeline carrying a fluid, describe (with the aid of sketches) what happens when a valve is rapidly closed in a long pipeline carrying water. *[5 marks]*

(b) Explain why an engineer should pay particular attention to such circumstances in designing a pipeline, and describe how the adverse effects of such valve closure can be mitigated. *[5 marks]*

3. An hydraulic model (e.g. using HECRAS) is required for use in the design of a flood protection scheme. List the various types of information required to construct the model. Describe the potential influence of the downstream boundary condition. Explain how to determine how sensitive the model outputs are to the downstream boundary condition. *[10 marks]*

4. A diversion channel is to be used to permit boats to bypass a reach of a main river channel that is unsuitable for navigation. Describe the main hydraulic factors that must be considered if the diversion, including any bridges, is to be safely navigable. If, when the diversion is constructed, water velocities under the bridges are too high for safe navigation, describe the options available for improving the situation. *[10 marks]*

5. Answer parts (a) and (b): *[Total 20 marks]*

(a) Outline how the impellers of commercial centrifugal pumps are designed to pump liquid and how their characteristic curves compare with those of axial flow pumps with particular reference to absorbed power profile, suction capability, possible modes of starting, efficiency curve profile and their differing functional use. *[8 marks]*

(b) A single duty KSB Omega 150-460 unit (416mm impeller) pumping water at 5°C through a system with the following system curve is fitted with a frequency inverter capable of altering the speed of the drive motor

Capacity (m^3/hr)	0	100	200	300	400	500	600
Static Lift + Dynamic Lift (m)	46	46.8	48.1	49.6	52.4	56.5	62.7

(i) Using the rectangular graph paper supplied (and/or the empirical KSB Omega/Omega V graphs on the supplied Page No. 42), find the operating point for the pump running at 1450 rpm using a 50Hz electrical supply. *[2 marks]*

(ii) If the frequency inverter is used to reduce the motor speed to 1250 rpm, calculate the consequent change in the pump capacity and the absorbed power. (See the 'Formula Handout' for the similarity ratios for a variable-speed pump and assume that, over the range of interest, the efficiency curves for 1450 rpm, on Page No. 42, apply also to 1250 rpm.) *[10 marks]*

6. Answer parts (a) and (b): *[Total 20 marks]*

Suppose that you have been asked to design a duty standby pumping set (pump shaft centreline level 12.5m O.D.) with a duty point of 750m^3/hr pumping water through a piped system having the following 'system-curve' data;

Capacity Q (m^3/hr)	0	200	400	600	800	1,000	1,200
Static Lift above max sump level (m)	65	65	65	65	65	65	65
Dynamic Lift (m)	0	2.1	4.0	9.2	17.5	32.3	57.8

The pump sump water levels can range from a maximum level of 11.0 O.D to the base of the suction pipe at 7.0m O.D and the cumulative suction form/friction losses at the duty point (750m^3/hr) total 1.8m .

(a) With reference to the pump characteristic curves for the KSB Omega range of split-case centrifugal pumps supplied with this examination paper (i.e. Page Nos. 2, 45, 50, 51, 56, and 57) and giving reasons for your choice, select the most appropriate pump for the delivery conditions stated above, your choice being that which also seeks to maximise the suction depth. *[12 marks]*

Part (b) overleaf!

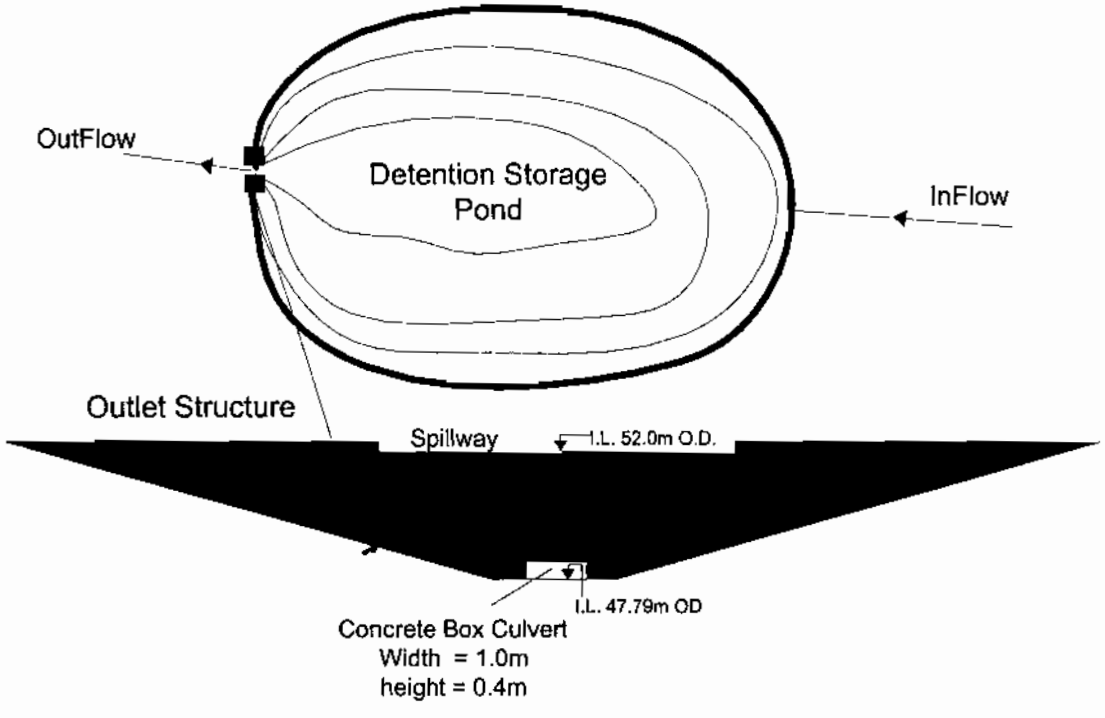
(b) Using your chosen pump graph, in association with the supplied system curve data, estimate the following at the designated duty point;

(i) the impeller diameter,
(ii) the $NPSH_{req}$ of the pump,
(iii) the absorbed power at the pump shaft, and
(iv) your recommended minimum rating for the pump motor.

[8 marks]

7. A flood alleviation scheme, involving flood water detention in a constructed pond, is proposed for an urban stream to prevent downstream flooding. The outlet from this pond will be controlled by a small box culvert 0.4m high by 1.0m wide which, during flood conditions, exerts a throttle effect on the outflow.

This outlet culvert is laid flat, having an invert level of 47.79m OD. A 10m wide spillway, having a crest level of 52.0m O.D., is provided to prevent flood levels exceeding the design height of the detention pond. (See the accompanying figure.)



(a) In this context, of culvert hydraulics, what do you understand by the term '*throttled flow*'? *[2 marks]*

(b) Determine the head-discharge relationship for the culverted outlet for a series of flood flows (1.0, 1.5, 2.0 and 2.5 cumecs) and present this relationship graphically. *[5 marks]*

(c) Determine the maximum discharge through the culvert such that the headwater level does not exceed the spillway crest level. *[3 marks]*

Question 8 overleaf!

8. (a) In the context of bridge hydraulics, what do you understand by each of the following terms?

(i) Unchoked flow

(ii) Low flow analysis

(iii) Afflux

(iv) Ineffective flow width

[4 marks]

(b) Identify and describe the various energy loss components associated with a motorway bridge crossing of a river channel and floodplain area. *[3 marks]*

(c) Discuss the various design steps that can be taken to minimise such losses. *[3 marks]*

END