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Study Of Submerssible Hydraulic Structures, A Critical Review

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ABSTRACT *Submersible hydraulic structures such as Fords and Raptas are preferred mainly in mountainous regions where hilly roads cross many torrential rivers enroot to save the cost of the highway projects. The proper design and location of these structures are an important issue as these structures have to serve two main purposes i.e. passing of river water and also to cater the traffic demand simultaneously. In this paper a critical review of few important causeways are carried out. An attempt has been made to critically examine the nature of scour and deposition around them in various flow conditions and changing geometry of the natural streams. It is found that generally there are two types of causeways, one in the form of plane concrete slab without any vent over which water and traffic both move while in another type there are vent for passing water from u/s side to d/s and traffic move over the causeways. In both types there is scour and deposition which depends upon many factors such as type of causeways, intensity of discharge, sediment size and curvature of natural stream. Suitable precautionary measures are also suggested to reduce the scour.*

KEYWORDS: Submersible structures, fords, causeway, scour, deposition

INTRODUCTION

Causeway is a road or railway route across a broad body of water or wetland raised up on embankment. Some causeways may only be usable at low tides and the distinction between causeways and via-ducts can become blurred when flood-relief culverts are incorporated in the structure. A causeway is however primarily supported on earth or stone, whereas a bridge or via-duct is mainly supported by free-standing piers or arches. Causeways (or Rapta) were constructed in ancient times by the people to save the enormous cost of construction of bridges and culverts at many locations where a single highway crosses many water bodies. The Traffic and cattle can easily cross the ever flowing rivers at very low depths throughout the year. At very high flow (Monsoon flood), a Rapta may wash away or a subsidized causeway has double functions:

(a) It allows the normal dry weather flow of a river/stream to pass through the culverts(vents) below the roadway and,

(b) The occasional floods pass both through the culverts and over the roadway.

Because they have this dual functions, causeways present hydraulic problems which are peculiar to this type of structure and great care should be taken with their construction. Many causeways have failed because of improper location or an improper design. If the culverts (vents) are concentrated in the centre of the causeway, the high speed water jets coming out of these culverts will cause heavy scour at the sides of the culverts. This implies that in designing causeways the culverts (vents) should be distributed evenly throughout the length of the structure.

TYPES OF CAUSEWAYS

According to IRC: SP: 82-2008(Guidelines for design of causeways and submersible bridges) there are mainly three types of causeways:

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(a) Flush causeway

In this type of causeway which is also called paved dip or road dam, the top level of road is kept same as that of bed level of the channel (Fig. 6). It is suitable where the crossing remains dry for most of part of year i.e. the stream is not perennial. Flush causeways are not suitable for crossing the streams with steep bed slopes causing high velocity even in low floods. The causeway covers the full width of the channel.

(b) Vented causeway

A causeway provided with vents to permit normal flow of the stream to pass under the causeway is known as vented causeway. Vented causeways are classified as low vented causeways and high vented causeways.

(i) Low vented causeway

Low vented causeways (Fig.7) are provided to cross quasi-perennial streams having sandy beds in areas with annual rainfall less than 1 m and where the carriageway of a flush causeway would be liable to get slushy due to post monsoon flow in the stream.

(ii) High vented causeway

High vented causeway (Fig. 8) is provided when a road crosses a stream having one or more of the following characteristics:

(i) Sizeable catchment area with annual rainfall more than 1 m
(ii) Depth of post monsoon flow is more than 0.9 m
(iii) Flow is perennial but not large
(iv) Banks are low necessitating construction of high embankment in the stream bed from considerations of the free board in non-submersible portion as well as geometric standards of approach roads

The height of the causeway above the bed is generally kept between 1.5mto3.0m and larger size of vents comprising of Hume pipes or simply supported/continuous R.C.C. slab superstructure over a series of short masonry piers or series of arches or boxes with individual spans less than 3m are provided.

CRITICAL REVIEW

The first causeway was constructed by British East India Company, during the tenure of Sir Robert Grant (1779 - 1838) as the governor of Bombay (1835 - 1838) as Colaba causeway. Its construction was completed in 1838, which used the Old Woman's Island as a part of it, with this the last two islands of Colaba and Old Woman's Islands (out of seven islands of the Bombay), which were first taken in 1675, got connected with the mainland of Bombay. Until 1839, Colaba was accessible only during the low tide, though soon it was rapid development in the area, especially after the construction the Cotton Exchange at Cotton Green in 1844. The causeway later further widened in 1861 and 1863. Colaba causeway now a days know as Culture Square of Mumbai.

MAJOR CAUSEWAYS OF WORLD

Notable causeways include those that connect Singapore and Malaysia (the Johor-Singapore Causeway), Bahrain and Saudi Arabia (25 Km long King Fahd causeway) and Venice to the mainland, all of which carry roadways and railways. In Louisiana, two very long bridges, called the Lake Ponchartrain causeway, stretch across Lake Pontchartrain for almost 38 km, making them the world's longest bridges (if total length is considered instead of span length). They are also the oldest causeways on the Gulf Coast that have never been put out of commission for an extended period of time following a hurricane. In the Republic of Panama a causeway connects the islands of Perico, Flamenco, and Naos toPanama city on the mainland. It also serves as a breakwater for ships entering the Panama Canal.

Causeways are also common in Florida where low bridges may connect several man-made islands often with a much higher bridge (or part of a single bridge) in the middle so that taller boats may pass underneath safely. Causeways are most often used to connect the barrier islands with the mainland

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The Churchill Barriers in Orkney are of the most notable sets of causeways in Europe. Constructed in waters up to 18 metres deep, the four barriers link five islands on the eastern side of the natural harbour at Scapa Flow. They were built during World War II as military defences for the harbour, on the orders of Winston Churchill

Doyle drive Low Causeway will span across the proposed Tennessee Hollow Creek restoration. Under existing conditions, there is no natural stream as the channel has been covered over and the runoff is conveyed in storm drains and as surface runoff. This report determines the water surface elevations, velocities and potential scour depths at the piers for the proposed Low Causeway. Following are the brief description of few important causeways:

(i) Lake Moondara Road Causeway

Stream Name:	Leichhardt River
Location:	50m down the Lake Moondarra road on the northern edge of Mt Isa township
Barrier Type:	Causeway
Height:	1m
Drownout Characteristics:	Drowns out on high flows, passage prevented on moderate to low flows
Other Barriers U/S and/or D/S:	None
Catchment U/S Barrier:	Large catchment upstream, permanent flow and pools in the Mt Isa reaches
Fish Passage Requirements:	Adult sooty grunter need to access spawning habitats upstream of the causeway.

(ii) Escott Causeway

Stream Name:	Nicholson River
Location:	15km west of Burketown
Barrier Type:	Causeway
Height:	1.8m
Drownout Characteristics:	Drowns out on high flow for periods of up to two weeks during the wet season.
Other Barriers U/S and/or D/S:	A number of low barriers on other crossings upstream
Catchment U/S Barrier:	Large catchment in good condition with low intensity grazing as the primary landuse.
Fish Passage Requirements:	Passage required on all flows at the site. Passage would be provided at high flows but would cease once flows drop and create a hydraulic jump across the causeway. This site already has a partially completed fishway channel built on the western end of the crossing. This could be easily modified to allow passage on low to moderate flows.

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(iii) Gin Arm Causeway

Stream Name:	Gin Arm Creek
Location:	20km West Burketown
Barrier Type:	Causeway
Height:	<0.5m
Drownout Characteristics:	Drowns out on high flow for periods of up to three weeks during the wet season.
Other Barriers U/S and/or D/S:	A number of low barriers on other crossings upstream
Catchment U/S Barrier:	Large catchment in good condition with low intensity grazing as the primary landuse.
Fish Passage Requirements:	Passage required on all flows at the site. Passage would be provided at high flows but would cease once flows drop and create a hydraulic jump across the causeway, this would only occur on very low flows.

(iv) Burketown – Doomadgee Road Causeway

Stream Name:	Gregory River
Location:	35km southwest of Burketown
Barrier Type:	Causeway
Height:	1.2m
Drownout Characteristics:	Drowns out on high flow for periods of up to two weeks during the wet season.
Other Barriers U/S and/or D/S:	A number of low barriers on other crossings upstream
Catchment U/S Barrier:	Large catchment in good condition with low intensity grazing as the primary landuse.
Fish Passage Requirements:	Passage required on all flows at the site. Passage would be provided at high flows but would cease once flows drop and create a hydraulic jump across the causeway.

(v) Doomadgee Causeway

Name:	Nicholson River
Location:	2km southeast of Doomadgee
Barrier Type:	Causeway
Height:	0.3m
Drownout Characteristics:	Drowns out on high flow for long periods during the wet season.
Other Barriers U/S and/or D/S:	Doomadgee Weir is directly upstream and Doomadgee Falls is directly downstream.
Catchment U/S Barrier:	Large catchment in good condition with low intensity grazing as the primary landuse.
Fish Passage Requirements:	Passage required on all flows at the site. Passage would be provided on all but very low flows, but is hindered by barriers close upstream and downstream.

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(vi) Road Causeway, Flinders River

Stream Name:	Flinders River
Location:	38km Southwest Normanton
Barrier Type:	Causeway
Height:	1.5m
Drownout Characteristics:	Drowns out on high flow for periods of up to two week during the wet season.
Other Barriers U/S and/or D/S:	A small number of similar causeways upstream, nearest one is 50km distant
Catchment U/S Barrier:	Large catchment in good condition with low intensity grazing as the primary landuse.
Fish Passage Requirements:	Passage required on all flows at the site. Passage would be provided at high flows but would cease once flows drop and create a hydraulic jump across the causeway

(vii) Burketown – Normanton Road Causeway, Bynoe River

Stream Name:	Bynoe River
Location:	34km Southwest Normanton
Barrier Type:	Causeway
Height:	1.5m
Drownout Characteristics:	Drowns out on high flow for periods of up to two week during the wet season.
Other Barriers U/S and/or D/S:	A small number of similar causeways upstream, nearest one is 50km distant
Catchment U/S Barrier:	Large catchment in good condition with low intensity grazing as the primary landuse.
Fish Passage Requirements:	Passage required on all flows at the site. Passage would be provided at high flows but would cease once flows drop and create a hydraulic jump across the causeway.

(viii) Burketown – Normanton Road Causeway, Little Bynoe River

Stream Name:	Little Bynoe River
Location:	32km Southwest Normanton
Barrier Type:	Causeway
Height:	1.5m
Drownout Characteristics:	Drowns out on high flow for periods of up to two week during the wet season.
Other Barriers U/S and/or D/S:	A small number of similar causeways upstream, nearest one is 50km distant
Catchment U/S Barrier:	Large catchment in good condition with low intensity grazing as the primary landuse.
Fish Passage Requirements:	Passage required on all flows at the site. Passage would be provided at high flows but would cease once flows drop and create a hydraulic jump across the causeway.

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(ix) Old Normanton – Cloncurry Road Causeway, Flinders River

Stream Name:	Flinders River
Location:	38km Southwest Normanton
Barrier Type:	Causeway
Height:	1.5m
Drownout Characteristics:	Drowns out on high flow for periods of up to two week during the wet season.
Other Barriers U/S and/or D/S:	A small number of similar causeways upstream, nearest one is 50km distant
Catchment U/S Barrier:	Large catchment in good condition with low intensity grazing as the primary landuse.
Fish Passage Requirements:	Passage required on all flows at the site. Passage would be provided at high flows but would cease once flows drop and create a hydraulic jump across the causeway.

CAUSEWAYS OF INDIA

The Colaba causeway is the one of the oldest causeways of India. It is constructed in the British regime during the tenure of Sir Robert Grant as the governor of Bombay, and its construction was completed in 1838. It connects two island namely Colaba and Old Woman's Island (out of the seven islands of Bombay) with the mainland of Bombay. The purpose of construction of this causeway was to avoid the overcrowded shipping, because by the beginning of 19th century, the Fort area and the part of the older town were over crowded so the boat traffic to that area increased in the next few decades, and several people died due the capsizing of overcrowded boats.

Few local causeways of district.Banda.in state of U.P. have also been cited in this thesis. Amongst these are Tigoria Nala causeway having length 25 m, width 7.5 m and depth as 2 feet. (0.60 m), Papreksha Pailani causeway also called Girganhnari rapta with length 25 m, width 7.5 m and overall depth as 2.5 feet and Garoati Nala. Tigoria rapta was constructed in 2005 and repaired in 2009. Similarly Ppreksha rapta was constructed in 1978 and repaired in 2009. Also Garouti rapta was constructed in 2006 and get repaired in 2009. About 40 lacs rupees was invested in these separate works.

Fig1.Garouti -Tindwari Causeway, Dist. Banda, U.P (Flush Causeway)

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Fig. 2 Low Vented causeway over PitesuNallah (Orissa)

Fig.3 High vented Causeway on Kewai River (M.P.)

Fig.4 Causeway on (Feccia River Italy)

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CONCLUSIONS

1. Causeways serve the economical rute to pass flow of water as well as the traffic in hilly regions where many torrential streams cross the highways/roadways. Thus saving the economy of project as a whole.
2. Three types of causeways may be constructed depending upon the site and traffic conditions.
3. Scour and deposition is a natural phenomena which takes place whenever the natural flow of stream get disturbed due to any obstacle which may be a ford, a causeway or any other similar structures.
4. The location of the structures should be considered at the time of the first survey when the preliminary alignment is chosen.
5. The care should be taken in the proper design i.e. fixing overall depth of causeway slab and its orientation. In no case a causeway should be provided where a stream has a meandering pattern to avoid excessive scouring and deposition.

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