# REVIEW PAPER ON DESIGN OF RCC BRIDGE AGAINST FLASH FLOODS

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## *I .Abstract-*

*Flash floods originate from innumerable rivers of size large and small which are subjected to floods mainly during monsoon season. Flash floods have peak discharge more than 50,000m /s. Country experiences devastating floods at least once in a year causing loss to life and property.. Along lifespan of Bridges are subjected to heavy floods as they are built across rivers when discharge coming from rivers reaches maximum there by resulting to scouring around bridge substructure leading to settlement of bridge. In this paper review is done on various works which includes the study of bridge subjected to scouring, Modifying the substructure of bridge to withstand flash floods , Studying flow patterns during flood and scour protection which is provided ` to piers in order to reduce the scouring. As substructure is the most important forming the structure of bridge where it is subject to lateral loads there is need to investigate suitable pier shape for reducing scour. Various studies have been studied to evaluate the flood resistant capacity of bridges , Main causes of failure of bridges after flooding and efficiency of scour protection measures .*

*Keywords-Flash floods; Peak discharge; Substructure; Scour; Scour protection measures.*

## II.INTRODUCTION:

Bridges are structures built to provide movement of vehicles where there is obstruction which is to be crossed . Bridges form a important role in trade and economy. Bridge consists of superstructure and substructure.

Super structure include

1. Deck slab,
2. Carriageway,
3. Footpath,
4. Trusses and girder sections whereas, Substructure include
1. Bearings
2. Piers
3. Abutments
4. Foundation of a bridge

## III.LOAD DISTRIBUTION IN BRIDGE:

Load distribution in bridge happens through following sequences:

- Deck slab provides support for movement of vehicles
- Load coming from vehicle movement is transmitted through bearings which are elastic nature
- Bearings transmit load to piers which experience lateral loads and transverse loads
- Piers transmit load coming from superstructure safely on to foundation and there by load is transferred to soil

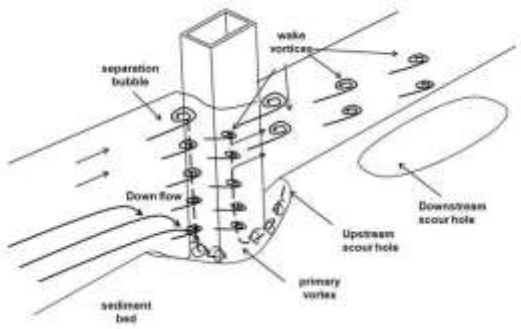
## IV.FLOODS AND ITS TYPES:

Floods are most common phenomenon in any region and therefore structures built upon any river or stream should have sufficient strength to retain the impact caused by sudden rise in discharge due to heavy rainfall for long hours . Based on intensity floods can be classified as

1. Fluvial floods
2. Coastal floods
3. Pluvial floods (flash floods)

## V.VORTEX GENERATED DUE TO FLOODS:

Vortex are eddy currents form when water flowing with high pressure lifting the sediment around pier and there by forming scour hole.The down flow at the front of the abutment is developed under the large vertical pressure gradient around the stagnation point of the approaching flow.




**"Fig.1" showing action of vortices leading to formation of scour hole.**

## VI. SCOURING ON BRIDGE:

Mostly the failure of any bridge will be scouring which is removal of soil around bridge pier which happens in flooding. Vortex flow and heavy downpour are main causes of local scour.

Scouring process will be initiated mainly due to fluid flow, distance between pier and pier surface characteristics. Local scour can be defined as removal of soil which is immediate surroundings to bridge pier. Scouring can take place through 2modes

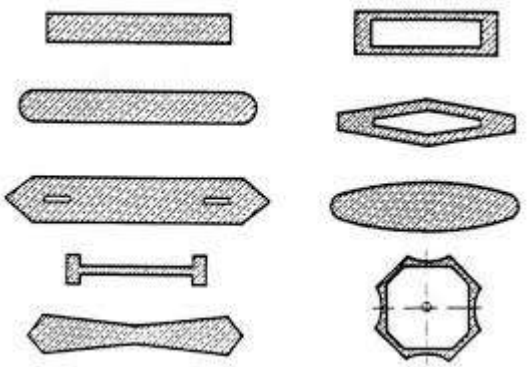
1. Clear water scour which can be defined when approaching water flow does not carries any sediments
through bridge piers
2. Live bed scour which can be defined as when approaching water flow carries sediments

## VII.SCOUR PROTECTION MEASURES

The effect of scouring can be measured through depth of scour hole which appears after receding of flood. The soil surrounding the pier is washed way after which the scour hole can be seen. So in order to reduce the magnitude of scouring the following measures must be employed.

1.Provision of rip-rap stones around bridge piers and abutments
2. Constructing hook collar around bridge piers
3.Placing devices like slot in piers which monitors the flow patterns

In addition to these modifying pier geometry has shown significant reduction of local scour around bridge. Experimentally six shapes such as Circular, Rhombus, Rectangular, Sharp Nose ,Octagonal, Elliptical were tested to withstand heavy downward approaching flow during flood Among these using octagonal shaped pier has shown 53% reduction in scouring compared to other pier shapes.



**"Fig.2" showing different pier shapes**

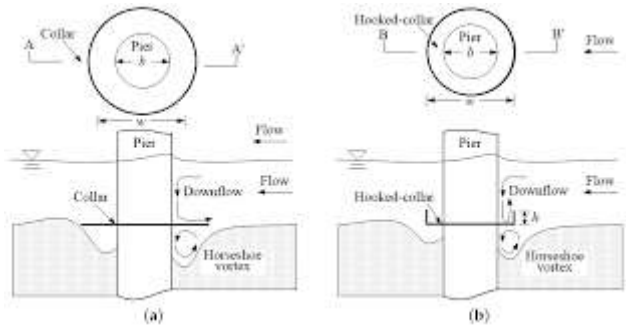
Scouring process is result of complex vortex system which is combination of wake vortex,horshoe vortex, trailing vortex and bow wave vortex that take place around bridge pier. The best countermeasure to restrict this problem is to use hook collar and cable as a modification to octagonal pier which reduces scouring to some extent.

## VIII .SCOUR REDUCTION AROUND PIERS:

Erosion of river bed around an structure and while water is flowing through structure is known as scour and the intensity of scour around pier is indicated by scour depth and local scour indicates immediate removal of sediment in the vicinty of piers and bridge abutments.

Local scour is complex problem which is the one of the important causes for the failure of the bridge.Excess local scour leads to rapid removal of soil around bridges causing imbalance to structure and there by damaging the structure.Therefore efforts should be made to determine the depth of scour hole for individual piers. Local scour is a result of material by which river bed is made of, Configuration of bed, Geometry of pier.It occurs due to interaction between velocity of water flowing around bridge and sediment around bridge foundation.To protect the bridge against local scour there is need of some type of embedment Pier modification is considered essential to reduce scour and providing collar, cable, openings, hooked collar were considered as most effective means of reducing scouring.

**"Fig.3"showing rip rap stones as a countermeasure to prevent scouring**




**"Fig.4" Schematic diagram showing provision of hooked collar around pier**

## IX. POSITION OF PIERS:

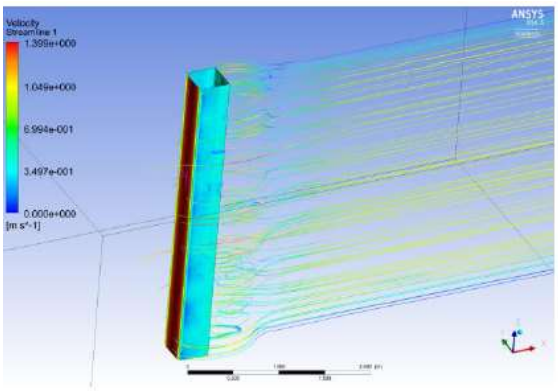
The study was conducted to know the placement of pier position in bridge in order to reduce effect of scouring . In this regard pier of three shapes were tested in laboratory such as circular shaped of 10cm, upstream facing round nose pier of 4-10cm and downstream facing round nose of 4-10cm. After testing results have shown that downstream facing round nosed pier is considered as effective countermeasure for reducing scour as it has reduced 54% of local scour around bridge

when compared to circular pier and 40% reduction in scour when compared to upstream facing round nose shaped pier.

Scouring counter measures basically falls under two types armoring countermeasures and flow altering countermeasures . The above one falls under flow altering countermeasure the main aim of flow altering countermeasure is to decrease the strength of downward approaching water flow which is main reason in forming vortex that will be leading to the scour. So by employing these pier shapes reduces the velocity of flow.

## X.Pier shape on flood loading:

Important parameters affecting the bridge pier design are resistance to flooding and debris whoch is accumulated around the pier.When heavy discharge flowing through bridge the piers and decks experience hydrodynamic loading. There is need to investigate effect of pier shape on flood loading.Piers with circular and sqaure cross-section are assumed for modelling and they are assumed to be fully submerged in water in order to avoid turbulence.

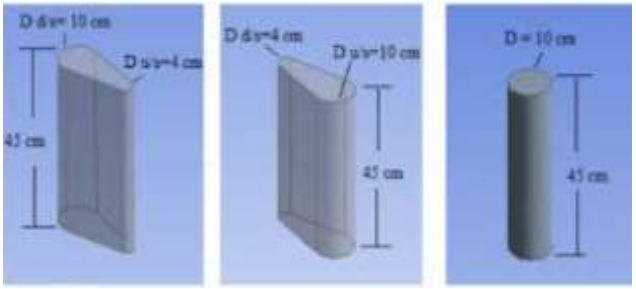



**"Fig.5" showing velocity around the pier**

From analysis it has been observed that when water flows through piers the positive and negative pressures are important for the design of stability of structure inorder to prevent localised damage.

Experimental investigation was conducted in laboratory to know the impact of position of bridge piers on the reduction of local scour around the pier.For this purpose three shapes such as circular pier, upstream faced round nosed pier and downstream faced round nosed pier were tested against the water flow to know the suitabilityfor reduction of local scour. Change in position of pier has resulted in reduction of downflow which is main cause for removal of sediment around pier and it has also shown the reduction of vortex infront of bridge pier.The flow velocity measurements were measured by Acoustic doppler velocimeter .Out of the results obtained downstream faced bridge pier has contributed to 83% of reduction of local scour when compared to circular pier and 40% reduction when compared to upstream faced round nosed pier.

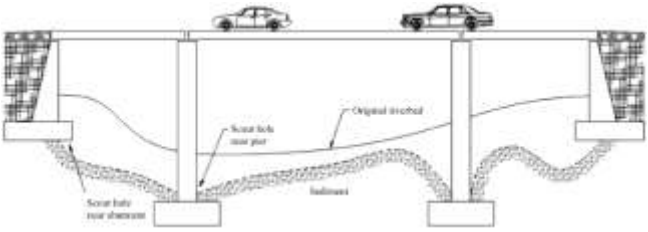
When compared to many countermeasures such as placing riprap stones and slots around pier this study suggests that changing the position of pier is considered to be one of the most effective countermeasure for reduction of depth of scour hole and local scour.




**"Fig.6"showing shapes of downstream and upstream round nosed pier and circular pier**

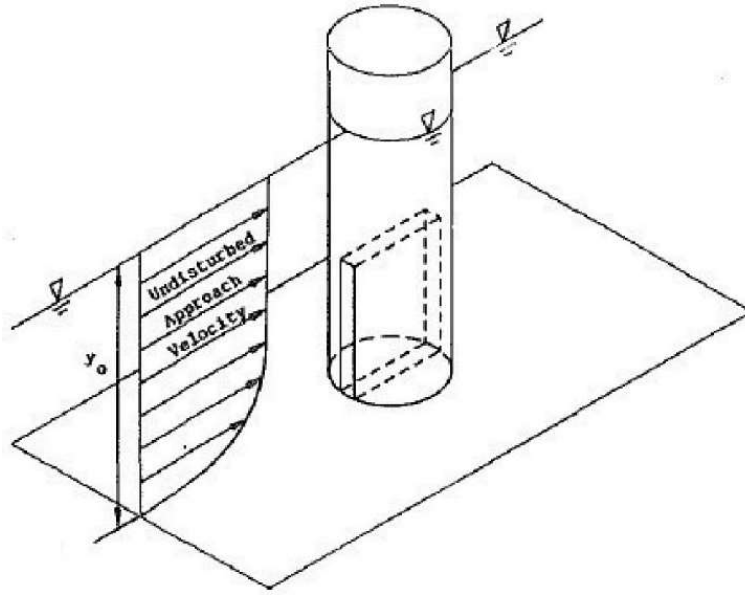
Among many reasons for scour failure the abutment scour is the most important reason for failure of bridge as it initiates the bank erosion in floodplain region. In floodplain regions the abutment scour can be more site specific whereas the pier scour can be more generic in nature.Failure such as shear failure and edge failure are more common types of abutment

failure which can be arised.Countermeasures such as arranging rip rap stones around bridge pier has to be followed inorder to arrest such type of failure.Though providing rip rap stones around pier prevents shear failure the other failure are most likely to combine and cause the eventaul damage to the bridge.Therefore the countermeasures are to be efficiently designed do that failures can be prevented. The limitation of using rip rap stones around bridge pier is that though it prevents shear failure it fails to provide solution for prenting other types of failure such s edge failure, bed degradation wlehich are mentioned earlier.



**"Fig.7".Showing schematic model of pier and abutment scour**

There are certain devices which are used in piers to monitor the scouring process which are employed for protection of pier against scouring.For efficient design of piers the scouring needs to be controlled .The performance of these devices will depend on how efficiently they monitor the scouring process.Apart from placing rip rap stones there are few countermeasures to reduce the depth of scour like providing array of piles to obstruct heavy downpour, placing collar and submerged vanes around pier. The vortices which are formed due to flow filed are main cause of local scour. These vortices are formed when a heavy downflow digs a hole infront of pier and there by resulting into scouring and it is measured by depth of scour hole.There are 2types of counter measures mainly flow altering devices and armoring deices among which the flow altering devices seems to be economical but it has its own limitations.The limitations are such as while placing slot the incoming flow which consists of debris can block the slot placed in pier which may result in blockage of monitoring the scouring process similarly whie placing the array of piles in front of piers if the flow takes the another direction then there will be no use in placing of piles.Therefore among many alternatives the application of providing collar seems to bereliable alternative and very effective means of protection against local scour.




**"Fig.8" showing slot device placed in pier monitoring downflow**

Therefore, six dierent pier shapes were utilized to find out the influence of pier shape on local scouring for a length–width ratio smaller than or equal to 3. A plain octagonal shape was shown as having more satisfactory results in reducing scour compared to other pier shapes. Furthermore, the efficiency of pier modification was then evaluated by testing different combinations of collar, hooked collar, cable, and openings within the octagonal bridge pier, which was compared to an

unprotected octagonal pier without any modification. The results show that by applying such modifications, the scour depth reduced significantly. The best combination was found to be a hooked collar with cable and openings around an octagonal pier. It was revealed that the best combination reduced almost 53% of scour depth, as compared to an unprotected octagonal pier experimental study aimed at assessing the most ecient pier shape in terms of reducing scour and also the capability of various pier modifications to minimize the erosive power of flowacting on the riverbed around that ecient pier shape. The work has extended previous published studies by considering six pier shapes (namely circular, rectangular, rhombus, sharp nose, octagonal and elliptical) and four pier modifications (namely collar, openings, cables, and hooked collar), underclear water conditions. The scour measurement was conducted whilst the flow was running. The scour development time history, equilibrium scour depth, and volume of scour hole were studied, together with the three-dimensional scour-hole profiles.

XII. DESIGN STUDY:

XII.1 LOADING CLASSIFICATIONS:

XI.1.1 IRC CLASS AA LOADING:

Loading is to applied within certain limits in subsist and industrial areas along major highways. Bridge which is to be designed for class AA loading is to be checked for IRC class A loading where in heavier stresses are obtained for class A loading

XI.1.2 IRC CLASS A LOADING:

This loading is adopted for all permanent bridges and culverts.

XI.1.3 IRC CLASS B LOADING:

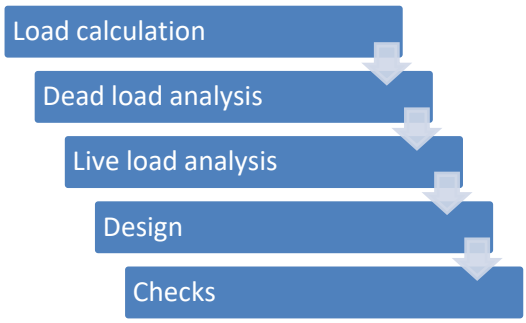
In this loading is adopted for all temporary structures and bridges

XII. Load Combinations:

**TABLE 1 LOAD COMBINATIONS**

| S.no | Carriage way width | Lanes for purpose of design | Load combination |
|---|---|---|---|
| 1. | <5.3m | 1 | One lane of width 2.3m shall be loaded with 500kg/m2 |
| 2. | 5.3m-9.6m | **2** | One lane of class 70R or 2lanes of class A |
| 3. | 9.6m-13.1m | 3 | All lanes of class A |
| 4. | 13.1m-16.6m | 4 | One lane of class 70R and 3lanes of class A |
| **5.** | 16.6m-20.1m | 5 | One lane of class 70R and 2lanes of class A with each lane. |

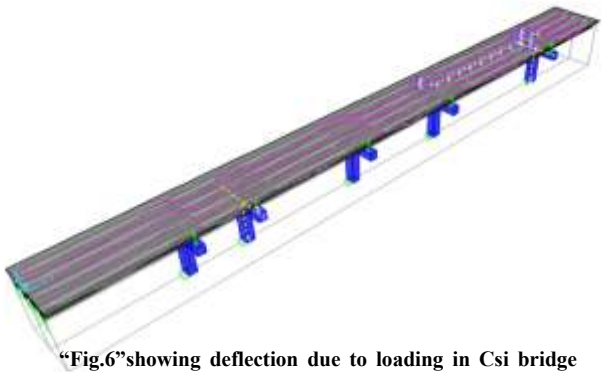
**XIII.DESIGN APPROACH:**




The following sequence is followed while deigning the bridge against flood loads.

**XIV.APPLICATION OF LOADS:**The loads applied on the bridge are as follows

1. Dead load



**"Fig.6"showing deflection due to loading in Csi bridge software**

## XVI. CONCLUSION:

Bridges during its lifetime will experience number of hydrdynamic loads which are lateral in nature due to which the substructure of bridge will be under heavy impact.Water while flowing through the bridge piers leads to formation of eddy currents which are known to be vortices which are mainly arised to obstruction such as bridge piers due to which stagnation of water takes place.All these process leads to main phenomena called

scouring which can be measured depth of river bed which is carried away during water flow which leads to depression in around pier of the bridge.There fore by selecting suitable shape of pier which can resist scouring should be done.Though countermeasures have been designed and developed to prevent scouring there is still so much need to provide accurate solution to address above problem

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