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Evaluation of Assorted Profiles in Bridge Pier Exposed to Exciting Flood Loading

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ABSTRACT

The global warming challenge is mostly the cause of floods today. Individuals everywhere in India had to deal with the impact of fluid load affecting bridges in the last 30 years. The latest methodology analyzed is a Finite Volume Technique (F.V.M.). In this research, actual dimensions of the bridge are used and for this, the data is collected from the Government of Maharashtra public works department (PWD Miraj). Also, Indian standard codal equations for pressure exerted on bridge pier are compared. For bridge pier modelling, square and circular segments are assessed. In addition to bed and sidewalls, consideration was given to simplifying the nonslip boundary of the stream for the fluid zone. The dimension of the fluid domain is 21 m x 23 m x 21.145m and the size of the pier is 1.5 m x 1.5 m. A numeric model with a water rate from 0.5 m/sec to 10 m/sec is established to test the impact of hydrodynamic pressure on the platform. The configuration conditions by all pier models are the same. Concerns about the effects of fluid flowing through a pier surface and pressure circulation combined with pier height are essential for this research. This study emphasizes that AS5100, I. R. C. 6, I. R. S. technique is ideal for a suitable conservative measurement of the pressure in square cross-section, but has a harmful margin of protection for circular cross-section bridge piers and hence can be used cautiously.

KEYWORDS: Hydraulic structures, F.V.M., Fluid load, Computational fluid dynamics.

INTRODUCTION

Many studies have focused on bridges that could be adversely affected by flooding. The issue of riverside bridges on the water has already been thoroughly researched. Researchers focused on conductive structural behaviour and ignored water drift. On the other side, fluid dynamics has been used to consider water drift, net power, Reynolds number and numerous computational models. Since the problem has fluid behaviour, fluid-structure interaction is the object of distinctive research.

Furthermore, the scouring and fluid-to-soil interactions are considered by engineers in other fields of C.F.D. Also, several field investigations on seismic damages due to recent strong earthquakes have confirmed the plastic hinges' decisive role in the pier's piles. Flood frequency analysis is generally carried out by fitting peak flow observations to a suitable probability distribution.

Confrontation to flood and particle loading is an obligatory constraint disturbing the bridge structure under fluid loading conditions. Flood intensity in the old years has been extraordinarily raised. Global warming engaged researchers to look over standard codes in bridges. Numerical and experimental research about the motion of a stream is based on the flow around a cylinder. Still highly complicated today, water distribution is an underexplored subject. To evaluate a bridge's responses to fluid effects accurately, it is

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imperative to perform a complete survey of the piers and the flow of water between them. We are using C.F.D. technology to discover that the water arrival is compared to the standards.

A pier is an increased bridge shape that usually has extensive columns or pillars. Piers serve as a support for the superstructure and serve as an entryway between the base and the ground. Piers are built to support vertical masses, as well as horizontal spans. To provide support for spans between abutments, a multi-support bridge necessitates supporting piers. Piers and abutments are located below bearings. Piers are usually constructed from brick masonry and stone masonry. Foundations support them.

As a flood affects a bridge pier, a distinct subject of investigation measures responsive reaction and cutting-edge glide pressure while considering fluid-structure interaction keen on justification. Though, relatively limited methodical studies continuously including the pier with fluid drift pressure have been conducted to look toward the impacting consequence, specifically when fluid-structure interaction is considered. Once flood affects the bridge pier, the pier produced in the drift is divided into two portions. The flood influences bridge pier with water streams around the pier. When the waft affects the pier, the flood's flow rate would be rapidly affected. The deteriorating bridge population and the limited amount of funds available for maintenance and inspection led to the development of bridge management systems to optimize the use of available funds by helping agencies take maintenance and rehabilitation decisions.

Details about Ankali bridge: Road Name-Nagpur Wardha Yeotmal Miraj Kolhapur; Type of bridge-Major bridge; Nature of bridge-High-level bridge; Exposure-Moderate; Length - 270.36 m; Width - 9.75 m including footpath carriageway; Two lanes; No. of spans and span length - 7 spans of 24.08 m each c/c, 4 spans of 25.45 m each c/c; Two abutments of 8 m on each side; Foundation type - Open foundation; Substructure-R.C.C., Year of construction –1998/99.

Figure (1): (left) Satellite view, (right) Side view of significant bridge across river Krishna on Nagpur Wardha Yeotmal Miraj Kolhapur road near village Ankali

Figure (2): Submerged Ankali bridge in flood situation arrived in 2019

LITERATURE REVIEW

This segment offers a widespread appraisal of the literature on various mathematical and investigational revisions for accepting the procedure in dissimilar types of shapes and loadings. Nasim et al. (2017) studied bridge pier under extreme flood loading. The water bodies should be fully or partially submerged, resulting in substantial loads on the deck and bridge piers. A correlation was provided among the corresponding hydro-static load recommended using Australian Standard 5100 code with arithmetical exploration. Yin-hui et al., 2015) examined the consequences on the bridge piers in water impact with fluid-structure interaction. The broadside helps understand the fluid flow impact outcome going on a pier.

Liang et al. (2016) mainly studied flood waves which are measured except for the straight hazard to human subsists, which may significantly influence the infrastructure, triggering physical destruction. Straight catastrophes are due to the quick catchment reaction near concentrated precipitation, openings of flood defenses, tidal waves or rainstorm flows. For full comprehension, the relationship between exciting drift hydrodynamics and hydraulic configurations is explored for different flow conditions. This paper introduces laboratory experiments and practices dignified information to authenticate a mathematical model.

Liu et al. (2019) conducted a study that aimed to explore the influence arranged on channel piers' performance and foundation piles in avenue construction operation. The feasibility of a retrofit mechanism was also tested through steel piece dividers to strengthen the passage balance. Zhou et al. (2018) examined the flood effect on piers accounted mostly in ANSYS-FLUENT software. The consideration of the influence of fluid, condition flows about a body related to a pier and dispersal in force combined with the pier elevation is a vital purpose of this analysis. Hung et al. (2014) considered the influence of scouring on the pier of a bridge exposed to flood loading. Retrofitting also affects the base of the pier to increase the susceptibility of the scoured pier of a bridge. Fang et al. (2018) examined structures of the existing coastline bridges, besides the outstanding allowance concerning the level of stagnant water and the minor triad of the top passage level. This broadsheet provides systematic enlightenment in hydrodynamic movement. Forces appearing arranged on a type girder passage level beneath hurricane are produced (Lukkunaprasit et al., 2011). The conventional method for estimating the hydraulic effect is entirely dependent on stand-alone pier model assessments. They used a solitary wave made in a flume of a wave.

Wang et al. (2019) considered the interaction of water and several circular tubes, subjected to earthquake and linear waves. In addition, practical finite element simulations have been implemented to quantify an earthquake-induced force in a detailed cross-section vertical cylinder (Fael et al., 2016). The balancing profile at uniform one-pier is determined by various variables, including the straight cross-section pier profile plus its flow-direction position perspective (Du et al., 2014). The time sector is mainly established on radiation concept which is a problematic hydrodynamic pressure term. In each case, the surface gravity wave which interplays through circular balanced, adaptable plates of the limited range was explored at a finite depth of water. The problems are considered based on the concept of minor amplitude moving fluid to the structural behaviour. Almasri et al. (2017) Studied the drag force which is typically practiced in the flowing river water on bridge piers. Established on drag constants defined in design codes and provisions, the force is determined empirically. While a wide variety of laboratory analyzes are available at bridge docks in flood conditions, the concentration of this paper is predominantly on severe floods.

THEORETICAL AND METHODOLOGICAL FORMULATION

The theory and technique of an analytical approach to influence shapes on the loading of floods are illustrated here.

Finite Volume Method (F. V. M.)

The intricate fluid-solid relations of the effects of floods remain directed by the Naiver–Stokes equation, wherein mass, momentum and power preservation are assessed. Arithmetic approaches have been developed for success in the perception of and the clearing of these equations, such as the finite volume method (F.V.M.), the finite difference process (FDM), as well as the finite element analysis (F.E.A.).

This paper's methodology is based on computational fluid dynamics (C.F.D.). This study aimed to see how the overall water flow pressure changes as the water velocity varies. Dual models which denote square and round cylinders are created mathematically to explain better how fluid pressure and distribution change as fluid velocity increases. F.V.M. is used in this analysis to assess the pressure distribution on cuboid and circular piers aimed at a broad assortment of flood rates.

The traditional finite difference approach is based on finite-dividing formulae to estimate the domestic expressions of derivatives of differential operators. First, an organized network of points is established and an area in the vicinity is linked to each end. These points are expressed discretely in the differential operators acting in the equations of the problem by the capacity of the finite formulae.

Finite Volume Method (F.V.M.) is a precise strategy in place of the discretion of a troubled field and the division into cells of the trouble field. The compilation of the equations for the discipline into the structure is required. Due to its versatility, the F.E. approach was used in several different areas with the necessary variations following the nature of the new problems with recognition of the F.D. approach and the best performance.

The finite volume method (F.V.M.) uses a combination of an approach to finite elements (F.E.M.) with a way of geometric versatility (F.D.M.) for simple, discrete computation. Because F.V.M. uses a significantly lower computing memory besides extreme calculation performance, it is predominantly well suitable on behalf of turbulent drifts through Reynolds number and source period dominant flows. In this way, the Naiver-Stokes formulae are conservatively inscribed before the discreetly controlled volumes are solved.

The assurance of flux management through a specific governor capacity is one of the most important advances in this kind of discretization, as shown in the following equation:

$$\int\int\int Q\ DV + \int\int F\ dA = 0 \quad (1)$$

where Q stands for variables preserved in vector form, F is vector flux, V is controlled element volume and A is surface area (Patankar, 1980). Hydraulic as well as hydrodynamic forces exist naturally and are used on bridges depending on the flow conditions. The point velocity determines these forces; when the rate is much lower than 10 m/s, a hydrodynamic force can be transmitted to a hydro-static force for generalization. However, there is no such limitation for AS 5100 (ASCE, 1994).

Considered Codes

In this study, various standard codes are under consideration concerning different codal provisions. This research work investigates the calculation of water flow force exposed to pier surfaces. For this, AS 5100, I.R.C. 6 and I.R.S. standards are used for theoretical comparisons. Table 1 gives a brief idea about formulae and their constant's.

Table 1. Various codal provisions regarding bridge design specifications

Australian Standard Code for Bridge Design Specifications (AS 5100.2 code, 2017)	Indian Road Congress for Design of Highway Bridges (I.R.C. 6 code, 2016)	Indian Railway Standard for Design of substructure and foundation of Railway Bridge (I.R.S. code, 2013)
The equivalent static drag load is determind by the equation: $F_{Drag} = \frac{1}{2} Cd\ \dot{\rho}\ \boldsymbol{V^2}\ A_d$	The force of pressure on piers similar to the way of the water current will be determined using the equation: $P = 52\ K\ V^2$	The water pressure on piers parallel to the direction of the water current is measured using the equation: $P = K\ A\ V^2$
Where, C_d is the coefficient of drag, $\dot{\rho}$ and V stand for the fluid density and speed, respectively. A is the surface area region in front of the stream. C_d has the following principles outlined for the various forms of piers. (a) piers in square ends = 1.4. (b) Circular or semi-circular piers = 0.70.	Where, P is the pressure intensity outstanding in the direction of water current (kg/m^2), V is the velocity current at the topic wherever the pressure intensity is determined, measured in m/s and K is a standard with the following values for the various shapes of piers illustrated. (a) piers with square ends = 1.5. (b) Circular piers = 0.66.	Where, P is the overall mean pressure in kg caused by water current and A is the area in sq. m. of elevation of the portion subject to water current, V is the maximum average current velocity in m/s. K is constant with values for pier shapes as below. (a) Square ended piers = 7. (b) Circular piers or piers with semi-circular ends = 35.

Construction of F.V.M. Model

In this study, the Ankali bridge pier having a circular shape with 1.5 m was taken as a case study. Another square shape is comparable to a circular shape. Both the piers have an elevation of 21.145 m, with a diameter of 1.5 m. In this paper, water flow velocity varies between 0.5 m/s and 10 m/s. Flow domain is having the size of 21 x 23 x 21.145 m in X, Y and Z directions, respectively. The flow domain is having a height of 21.145 m as the submerged condition is considered in this study. Velocity increments are considered as 0.5 m/s for each setup.

Table 2. Details of components of bridge pier

Sr. No.	Component	Section (m)
1	Circular Pier	1.5 Dia.
2	Square Pier	1.5 x 1.5
3	Pier Height	21.145
4	Flow Domain	21 x 23 x 21.145
5	Fluid Velocity	0.5 – 10 m/s

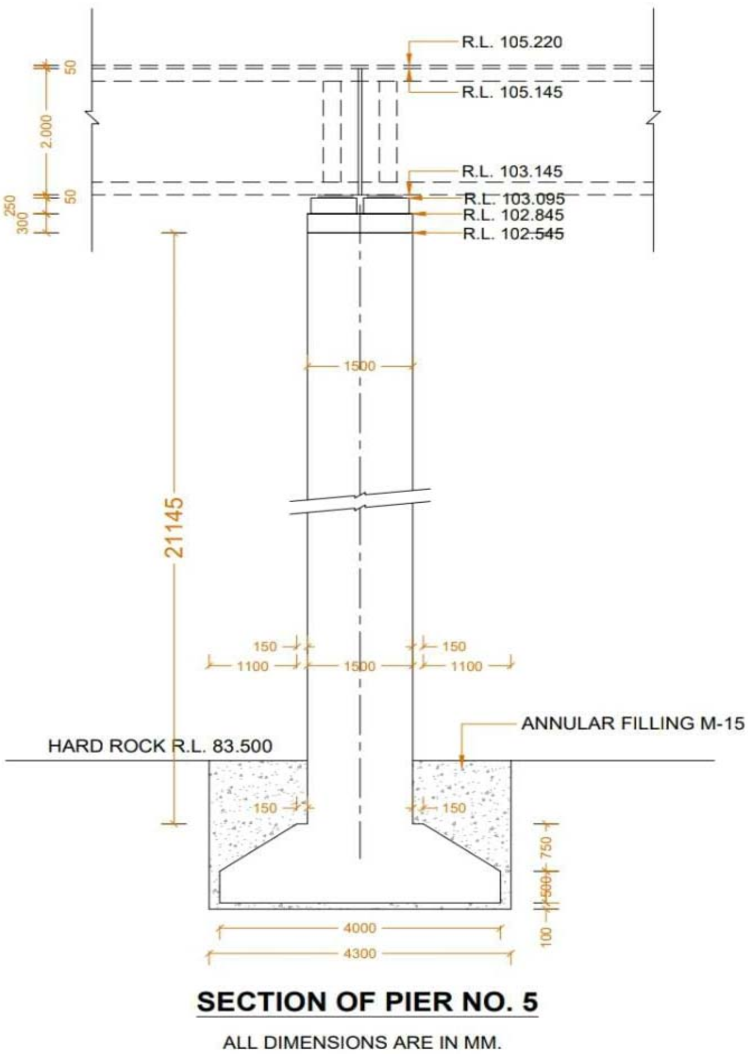


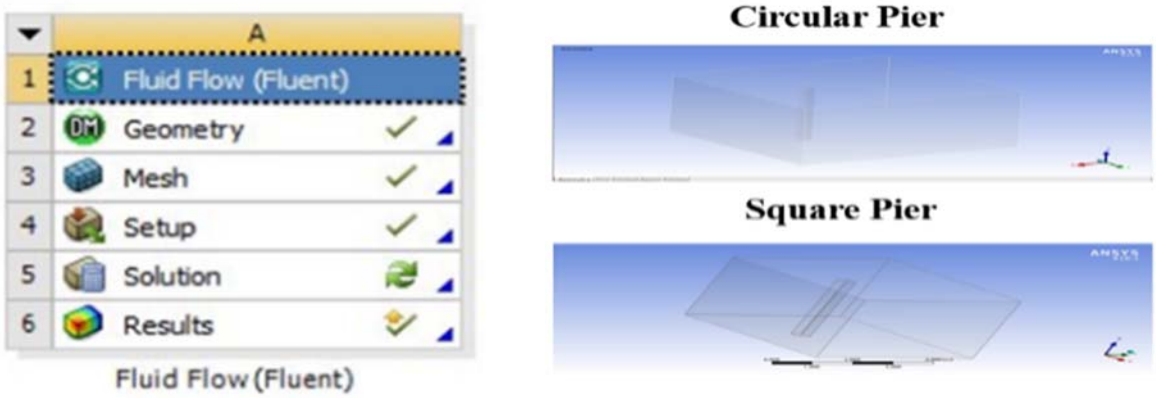
Figure (3): Section of newly constructed Ankali bridge pier no. 5 (P.W.D., Miraj)

Fig. 3 shows a section of circular bridge pier no. 5 with dimension details. While designing the Ankali bridge pier, the shape of the sub-structure is also such that it will not be added to the turbulence of flowing water.

Geometry Creation and Detail Information of the Model

The pressure differences were tested for a large number of fluid speeds from near-still water to flash flooding. Because the behaviour of the structure was not significant at this point, the bridge pier was demonstrated as an unstructured model as a circular cavity. This implies that the pier's boundary was supposed to be nonslip walls as a channel wall boundary state. During these exercises, the pier of the Ankali bridge shown in Fig. 3 was taken as a case study.

A circular pier structure is a common type of aging structural configuration in India. A square model is equivalent to a circular tube of a similar width. According to previous research, cuboids should be 14 D in diameter, where D is the breadth of a body wide-open to fluid. For instance, Zhang (2017) found 14 D width adequate. According to the suggestions above, a fluid drift field in the X, Y and Z directions was used in the analysis, contained in a cuboid of dimensions 21 x 23 x 21.145 m, as shown in Fig. 4. The setup conditions for both square and circular forecasting models were the same, as shown in Fig. 5. Following boundary conditions are used for analysis; first inlet is the velocity inlet with a range of 0.5 m/s to 10 m/s with an increment of 0.5 m/s. The boundary outlet is a type of outflow. The remaining boundary condition for sides is a type of wall. The domain for the pier is solid. Velocity and pressure are used as boundary conditions in a domain.



(a) (b)

Figure (4): (a) Modelling hierarchy, (b) Geometry for circular and square-shaped piers

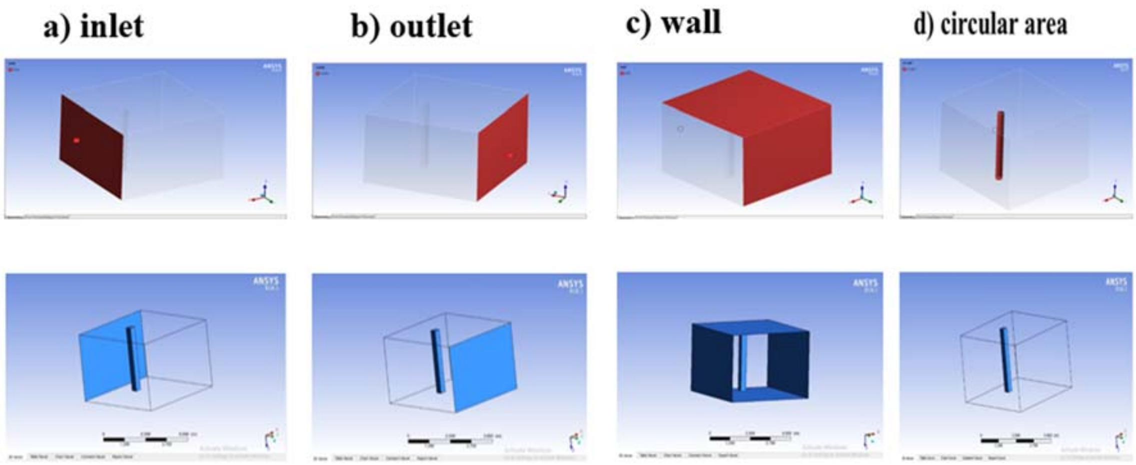
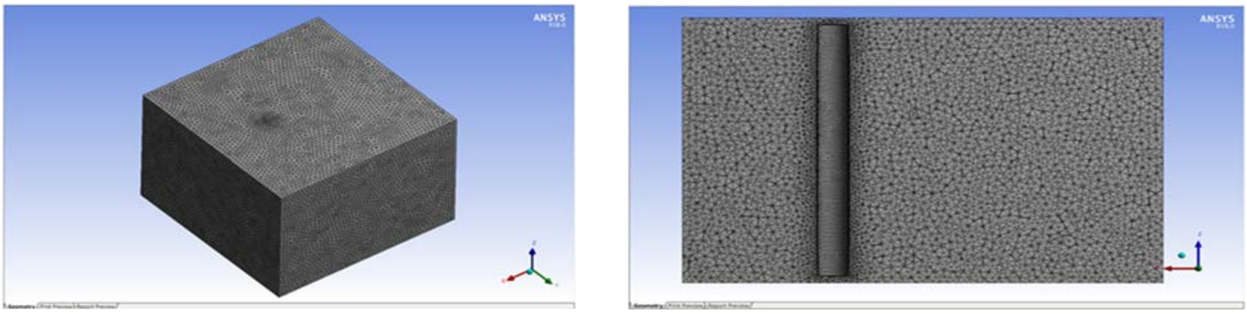


Figure (5): (a), (b), (c) and (d) represent the setup for boundary conditions in circular and square-shaped bridge piers



(a) (b)

Figure (6): (a) Meshing setup for model pier (b): Meshing section of the circular pier

To get an improvement in the outcomes, the current study's arrangements are done with tetrahedral meshing in all cases. The technique adopted for the flow domain is the patch conforming technique. Here, the dimensional function is uniform and the relevance centre is occupied as acceptable. It is kept high for smoothening, as shown in Figure 6 (a and b).

Model Construction and Validation

We used a commercial CFD tool (ANSYS Fluent) to show the numerical simulation for the bridge's piers. The circular and rectangular piers are schematically modelled in Fluent. It is noted that the flow domain is restricted to a cuboid with a size of 5 × 7 × 3.5 m in X, Y and Z directions, respectively. To get an enhancement in the results, the present study deals with tetrahedral meshing in both cases. The method used for the flow domain is the patch conforming method. Here, the size function is uniform and the relevance centre is occupied as acceptable. For smoothening, it is kept high. The minimum size generated for the cell is $2.2082e^{-04}$ m.

The details are associated with Nasim's (2018) study data in Fig. 7. As predicted, the water flow rate is growing at the edges of the pier and decreases close to the area and the slippery walls. Results of circular and rectangular models are validated with Nasim's (2018) pressure as shown in Figs. 7 and 8.

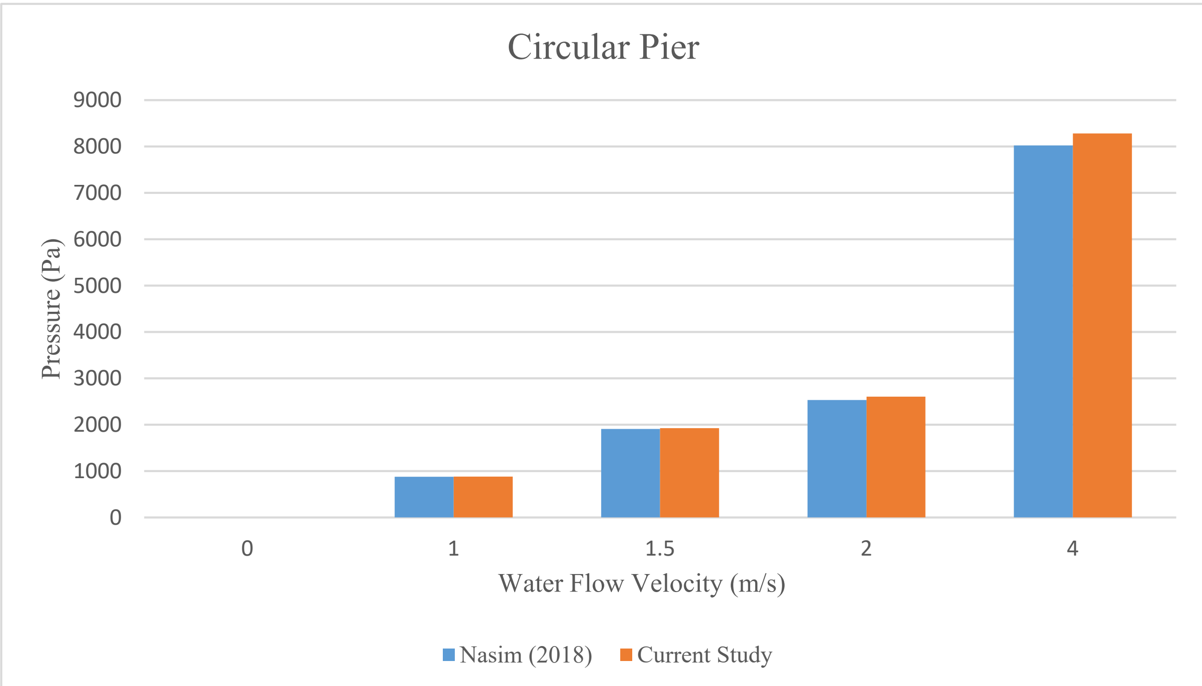


Figure (7): Pressure at the pier with the circular section *vs.* Maryam Nasim (2018) circular section pressure

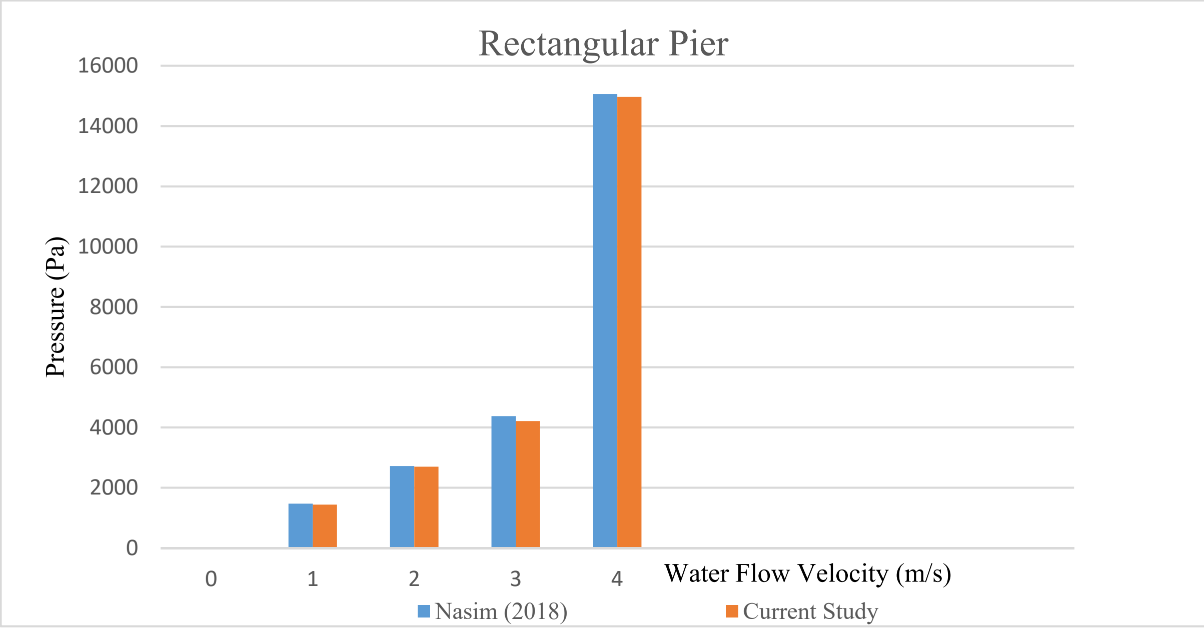


Figure (8): Pressure at the pier with the rectangular section *vs.* Maryam Nasim (2018) rectangular section pressure

The outcomes of the model were associated with the studied methodology (Nasim, 2018). For the speeds of 1 m/s, 1.5 m/s, 2 m/s and 4 m/s, the bar graphic representation in Figs. 7 and 8 equates pressure in the rectangular and circular versions. The values for lower speeds, which are less turbulent, will be very similar as predicted. On the other hand, the difference becomes essential as the speed of water flow increases. We have nearly matching results. Results compared with Nasim pressure express agreement (Nasim, 2018).

This case reveals an empirical and numerical study of the various forms of a pier subject to flood loading. It has been determined that, with the aid of ANSYS Fluent in the use of complex analysis procedures, the flood situation with a large number of pier forms and loading circumstances can be explored effectively. The present study considered the pier as fully submerged and having critical condition. The focus of this study was water distribution. The numerical model is a single phase. Moreover, it is possible to specify the precise positive and negative pressure, reducing the time needed to operate an experimental device to test the pier's material properties for extraordinary forms in water bodies.

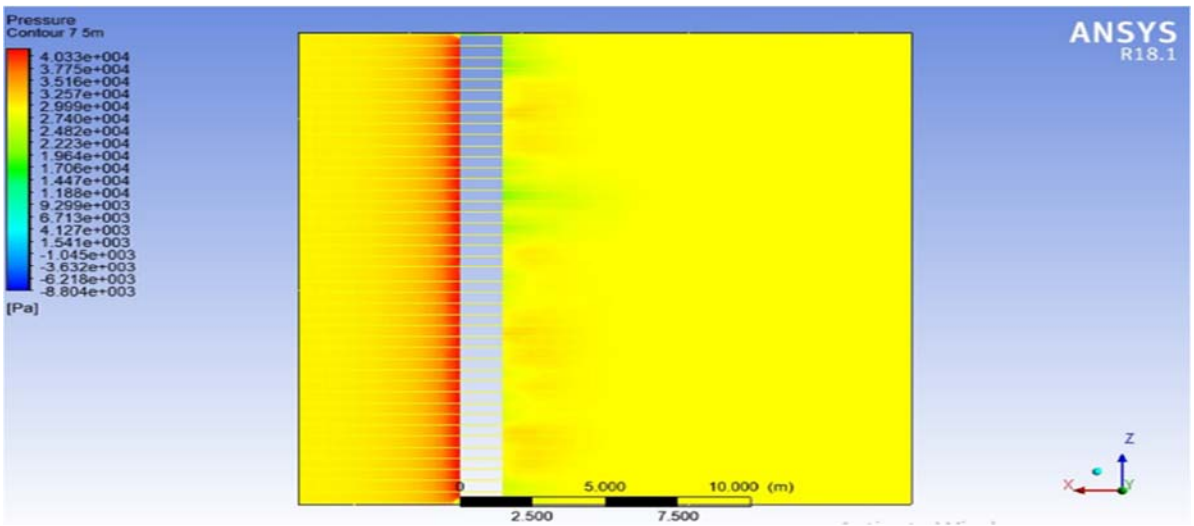


Figure (9): Pressure contour for a circular pier with an inlet rate of 5 m/s

Based on this finding, pressure *vs*. pier height is given to the positive and negative pressure dispersals alongside the pier. The total fluent pressure was determined by adding hydro-dynamic and hydro-static force pressures derived from water flow subsequently to an entity. Fig. 9 shows circular pier pressure obtained from C.F.D. analysis at an inlet velocity of 5 m/s. The pressure increases as predicted as the flood speed increases; however, for various water current speeds and actual identical distribution alongside the pier height, the total pressure distribution takes a related pattern.

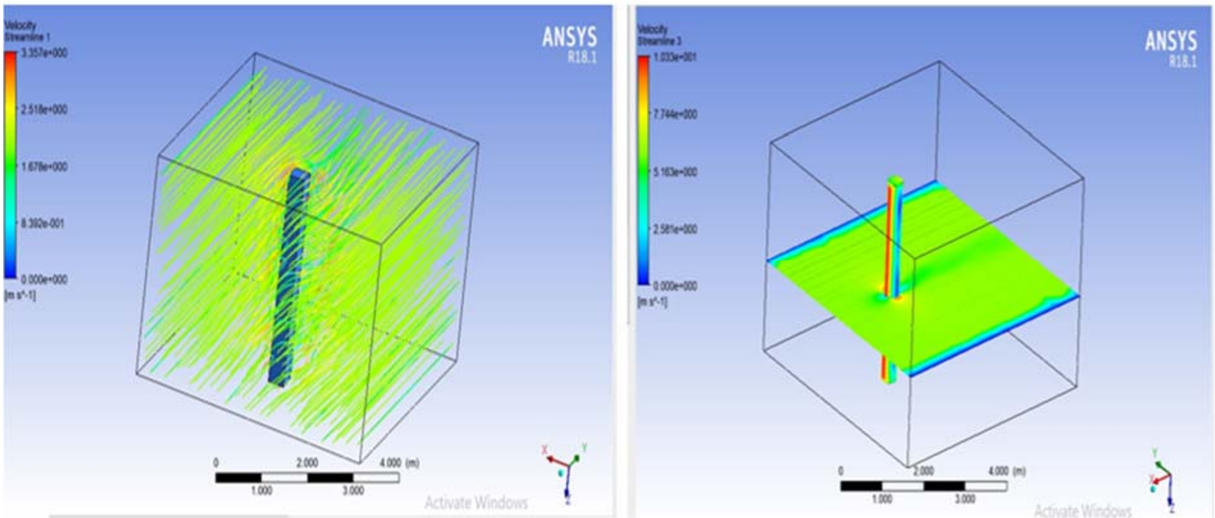


Figure (10): Velocity streamline for a square pier and a circular pier

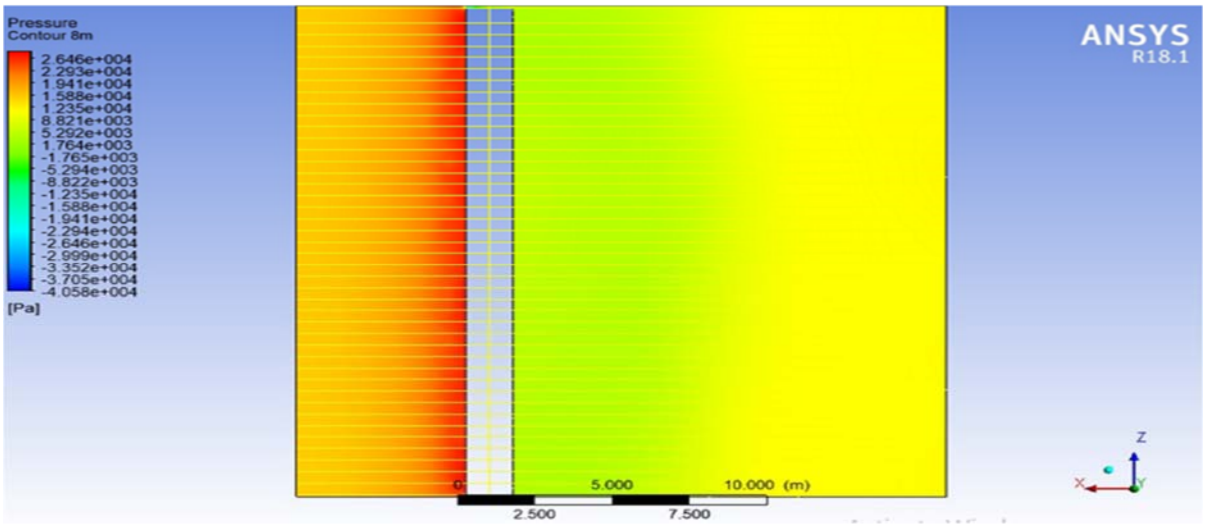


Figure (11): Pressure contour for a square pier with an inlet rate of 5 m/s

Comparison between the Analytical Results and the Codal Provisions

A mathematical model has been developed to examine the distribution of the pressure on piers for square and circular cylinders representing the pier of a bridge and the requirements of the existing bridge proposal requirements for AS5100.2 (2017), IRC6 (2016) and I.R.S. (2013). A 3D finite volume method used for the incompressible model with Navier–Stokes is developed in this study and was investigated with the software ANSYS Fluent on every square and circular cylinder. This study focuses on water as a flowing fluid and non-structural elements around a pier to measure the overall water pressure on the immersed pier.

A plane curvature through a continuous rate (other than topmost and low) is shown by the overall pressure distribution on the square pier and its height when considering the circular pier. An actual perpetual pressure rate fluctuates about the pressure distribution. The standards on the circular shape pier are consistent with those on the square pier (except for top and bottom). The negative pressure taking place crosswise of the pier differs significantly. It is understood that the negative pressure proceeding the square pier by more incredible velocity was substantial. In contrast, the negative pressure from the circular pier on the other side of the topic was marginal and erratic. It is best to presume that the piers are fully under water when allowing for the critical flood situation (Australian Standards, 2017).

Analysis of Water Pressure Using Various Standard Codes

Different codes in India and outside the country specify methods of calculation for determining water flow pressure. The Australian bridge design code (AS 5100.2 code, 2017), Indian Road Congress for Code Design (I.R.C. 6 code, 2016), Indian Railway Standard for Sub-structure Design and Railway Bridge Foundations (I.R.S. code, 2013) are the methods established in Table 2. The measurement methods for the water flow force in different codes are identical to Table 2. The formulations used in these codes are identical with wording, although the signs in formulae often have like definitions, except that bridge pier resistance values differ. For example, the value of a bridge pier for form resistance is set as 0.7 for AS 5100.2, with values of 0.66 and 35 in I.R.C. and I.R.S. codes, respectively. They are taking the circular pier of the column as an example. The value for the square column pier for bridge pier is set to 1.4 in AS 5100.2, 1.5 in I.R.C. and 79 in I.R.S. code, respectively. The value is 1.2. for the square column pier as an example.

The average positive and negative pressures detected scheduled in circular pier by the side of velocities ranging from 0.5 m/s to 10 m/s are shown in Fig. 12. From this figure, the circular pier negative pressure is negligible and more irregular concerning positive pressure. The form has an integral impact on the water flow forces. For the circular pier, fluid motion is moving through its circumference. That is why in a circular pier, negative pressure is negligible.

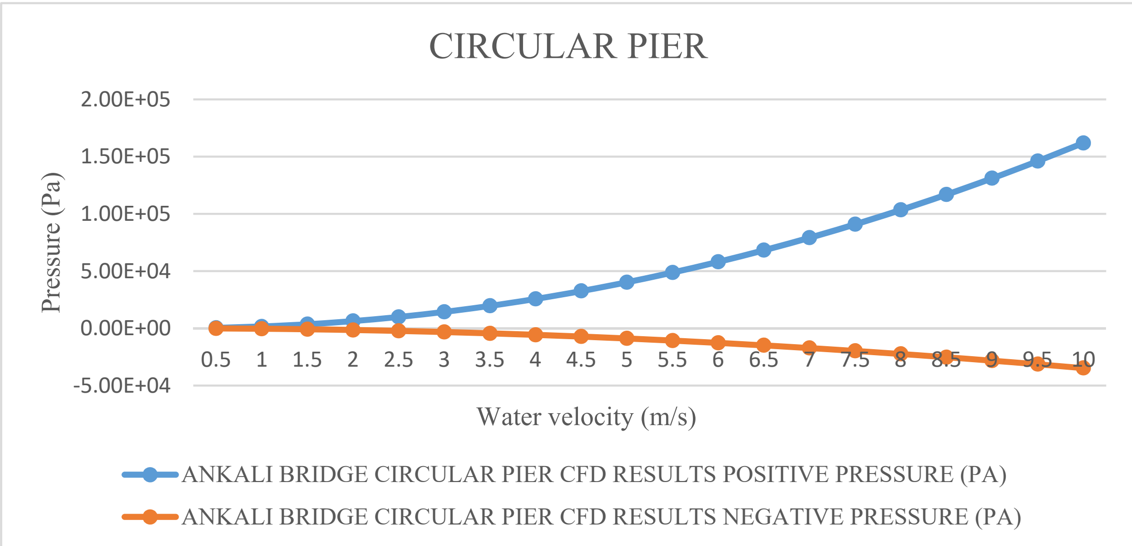


Figure (12): Circular pier C.F.D. positive pressure and negative pressure results

The average positive and negative pressures detected off the circular pier at velocities ranging from 0.5 m/s to 10 m/s are shown in Fig. 13. From this figure, the square pier negative pressure is more concerning than positive pressure.

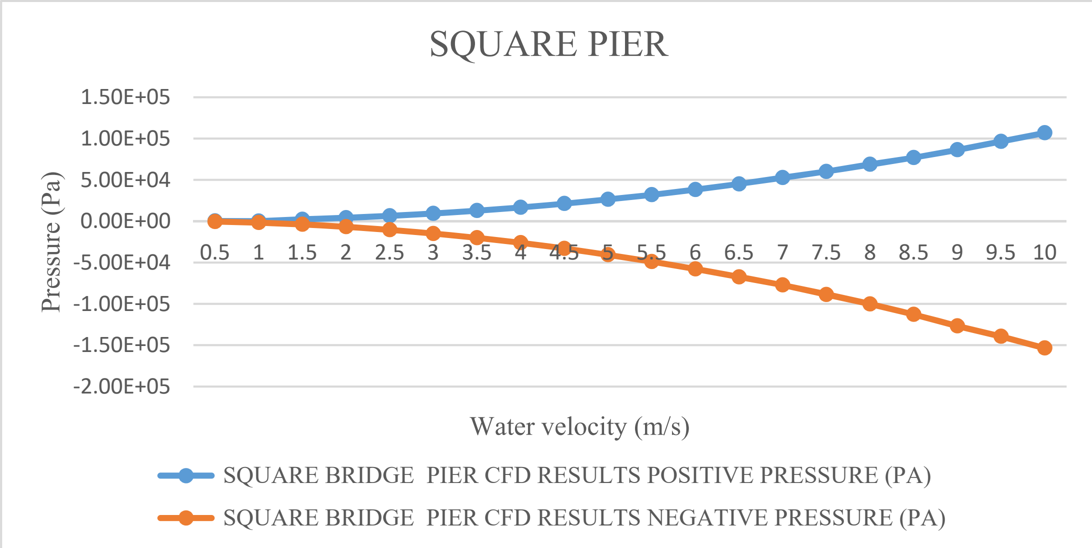


Figure (13): Square pier C.F.D. positive pressure and negative pressure results

For the square pier, fluid motion is obstructed on the edges of the pier. Due to this, more vortices are generated. Due to this, the square pier negative pressure is more concerning than positive pressure. For a circular pier, C.F.D. results are compared with individual standard codes. Comparisons of positive pressure results with AS 5100 equation shown in Fig. 14. The difference between values becomes more significant from a water flow velocity of 5 m/s. Comparison of positive pressure result with I.R.C. 6 is shown in Fig. 15. The difference becomes noteworthy at a water flow velocity of 5 m/s.

Comparisons of positive pressure results with the I.R.S. equation are shown in fig. 16. From dissimilarity becomes remarkable from water to flow velocity 5 m/s.

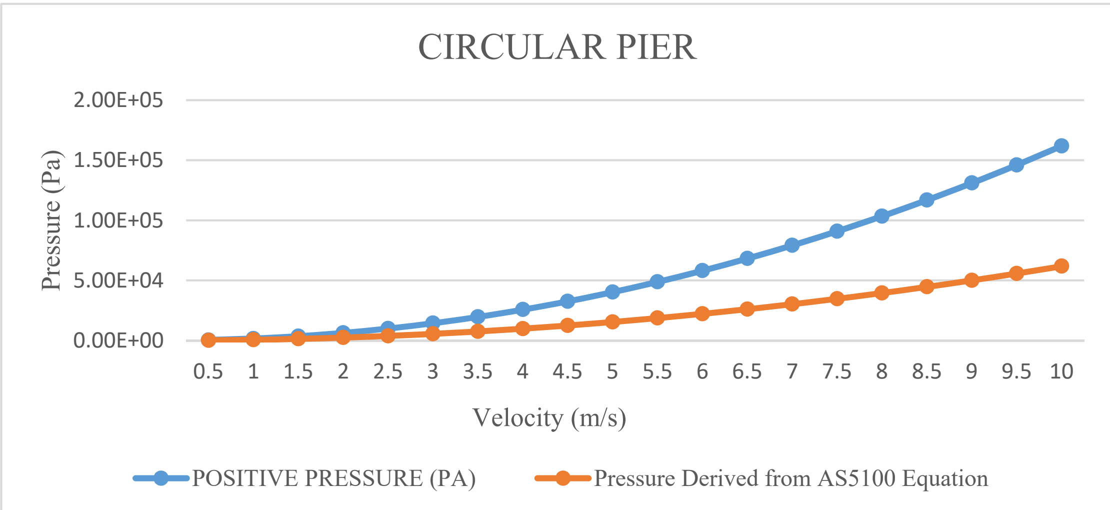


Figure (14): Comparison of circular pier C.F.D. positive pressure results with AS5100 code equation

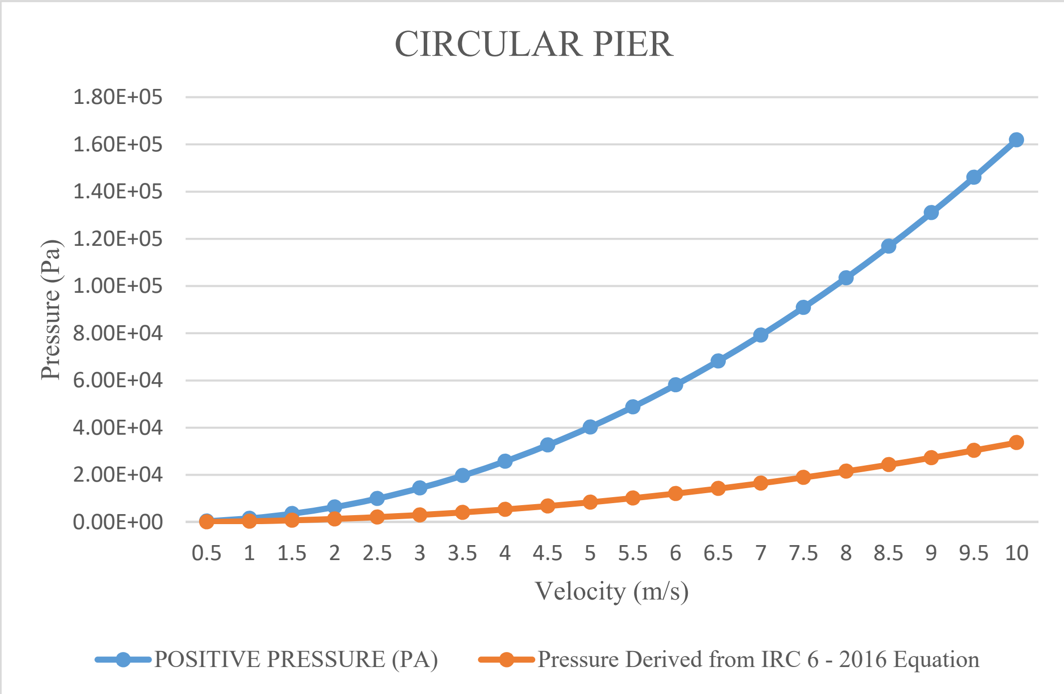


Figure (15): Comparison of circular pier C.F.D. positive pressure results with I.R.C. 6 code equation

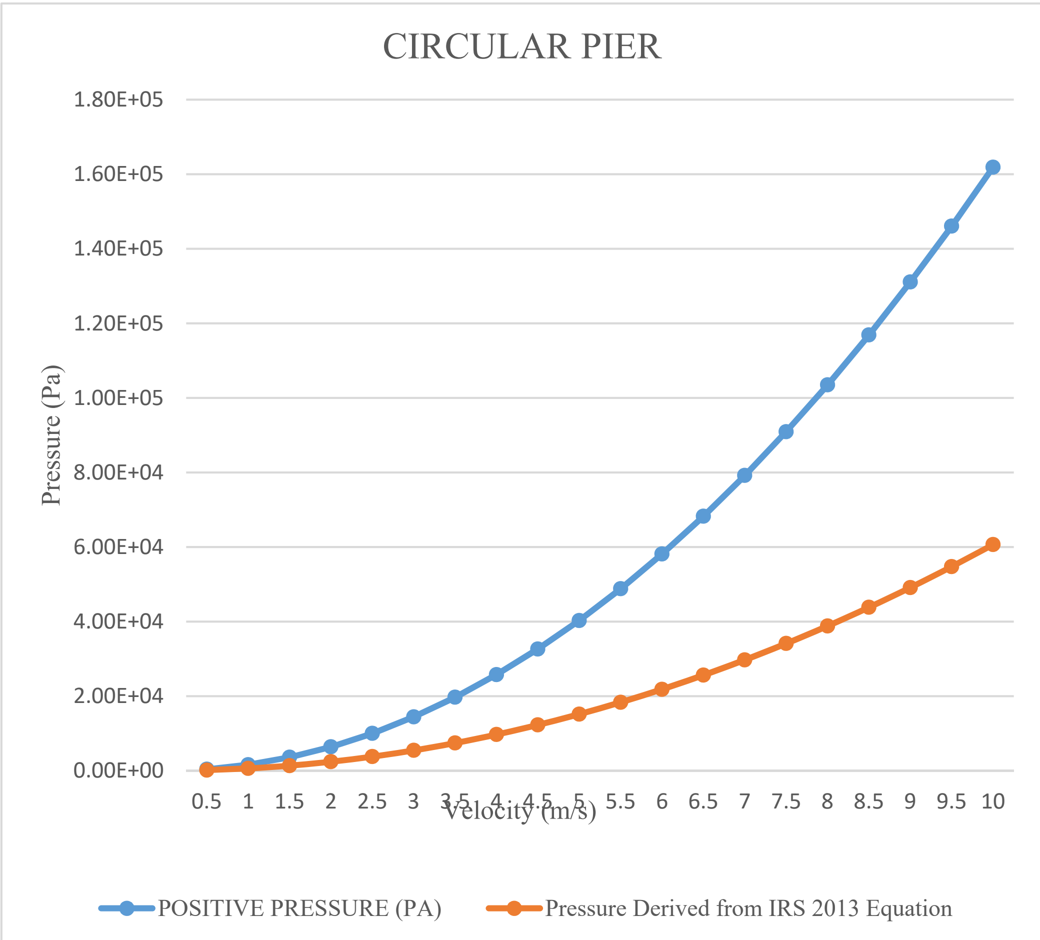


Figure (16): Comparison of circular pier C.F.D. positive pressure results with I.R.S. code equation

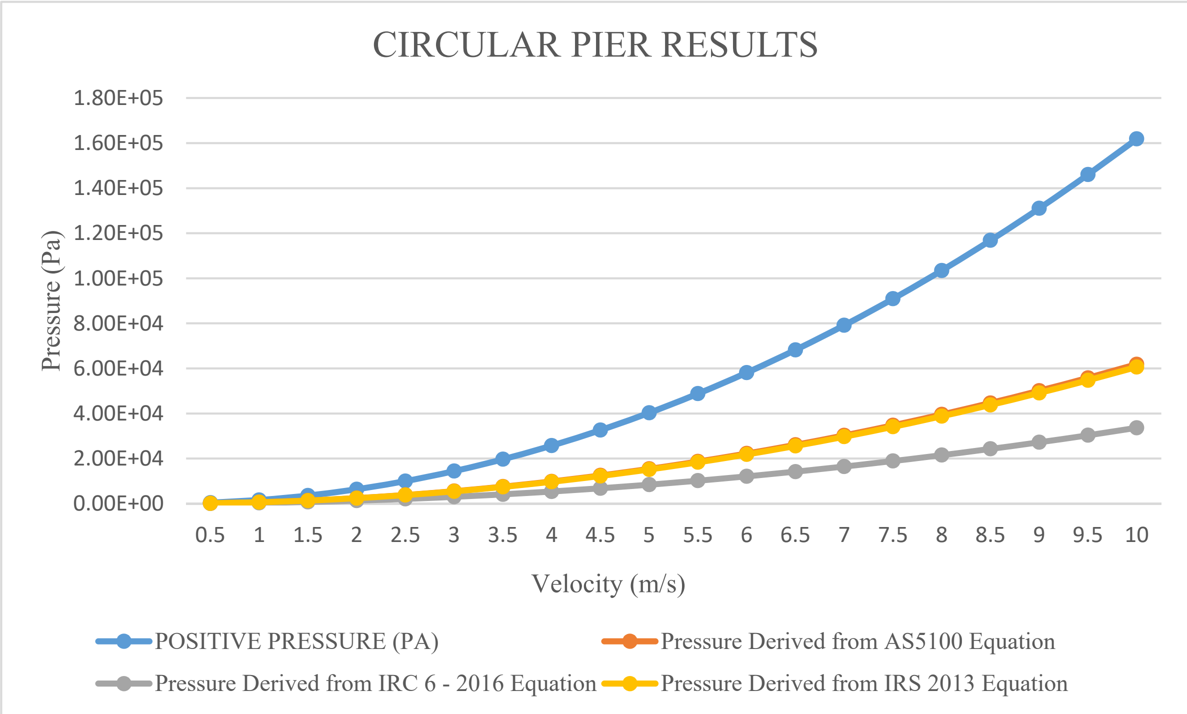


Figure (17): Comparison of circular pier C.F.D. positive pressure results with various code equations

A C.F.D. simulation was used to derive pressures. The positive pressure obtained contrasts with the code AS5100:2:2017 suggestions, I.R.C. 6:2016 code and I.R.S.:2013 code, as shown in Fig. 17. Though the negative pressures on the circular pier are not considerable, the combined positive and negative pressures are very similar to the pressures measured for the code comparison.

They are also somewhat underestimated for speeds of less than 5 m/s. Figure 17 shows that for smaller speed of water, the values of pressure are very close, since fluid is less turbulent. As we increase fluid velocity, the difference becomes more with increased turbulence in the fluid domain. This result demonstrates that for circular pier, compared standard equations are not conservative. It could be inferred that this circular pier was analyzed using the C.F.D. The calculation method represented in the standard equation is not conservative.

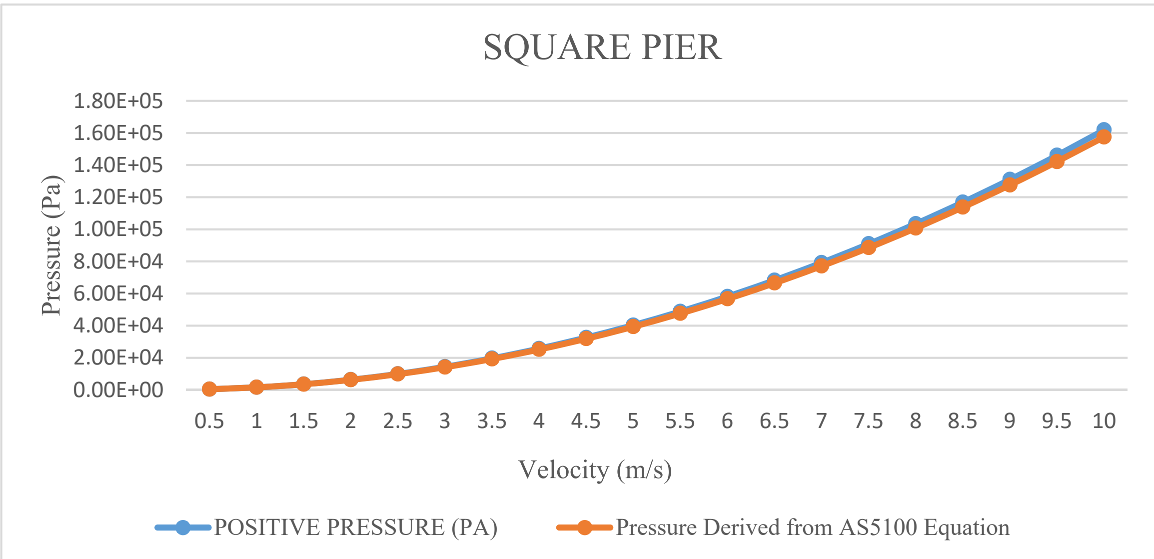


Figure (18): Comparison of square pier C.F.D. positive pressure results with AS5100 code equation

For square pier, C.F.D. results are compared with individual standard codes. Comparisons of positive pressure results with AS 5100 equation are shown in Fig. 18. From this figure, it is proved that square pier has an agreement with codal provision. Comparison of positive pressure result with I.R.C. 6 equation is shown in Fig. 19. From this figure, it is evident that square pier has an agreement with the codal provisions. Comparison of positive pressure results with the I.R.S. equation is shown in Fig. 20. It becomes remarkable that water flow pressure for the square pier has accurate results that agree with code provisions.

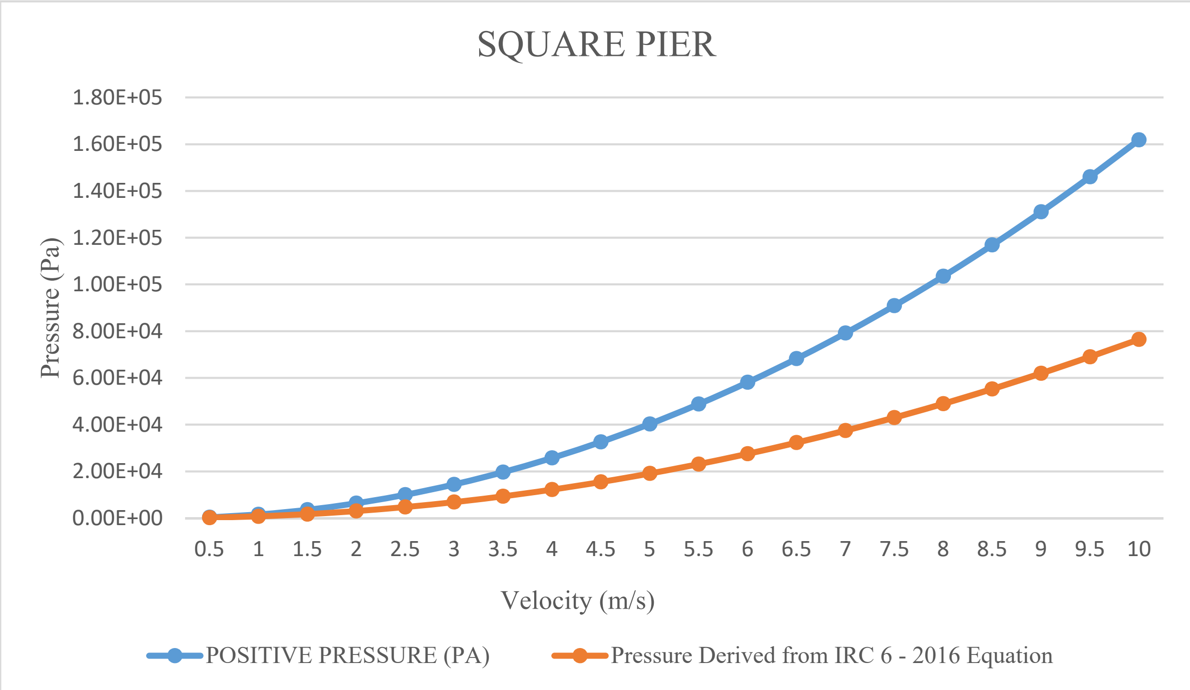


Figure (19): Comparison of square pier C.F.D. positive pressure results with I.R.C. 6 code equation

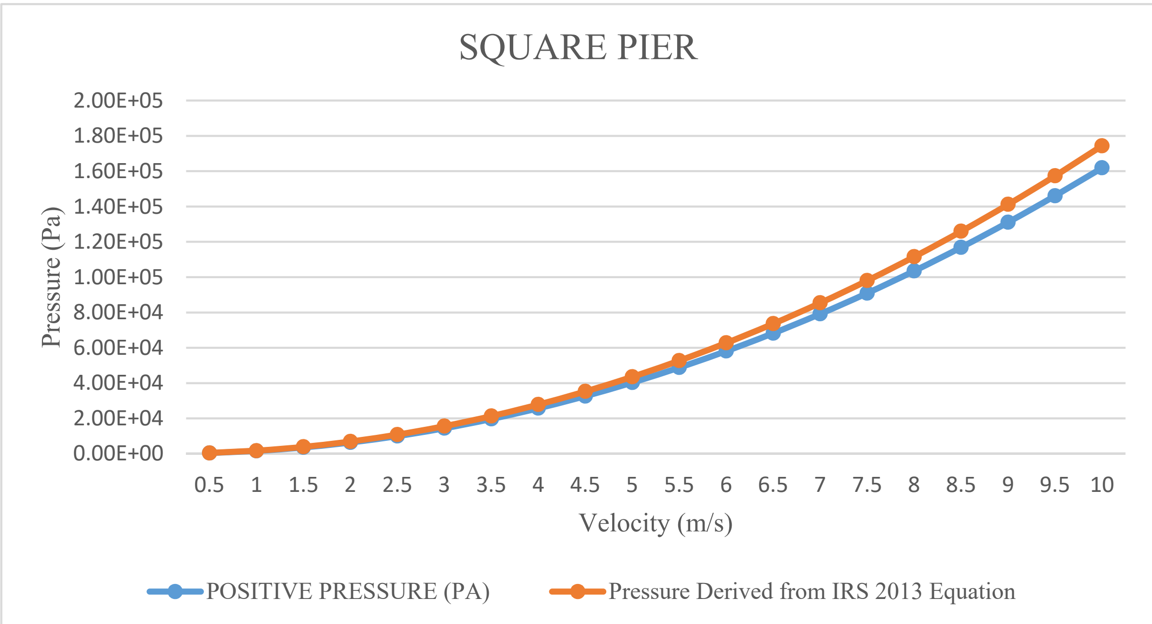


Figure (20): Comparison of square pier C.F.D. positive pressure results with I.R.S. code equation

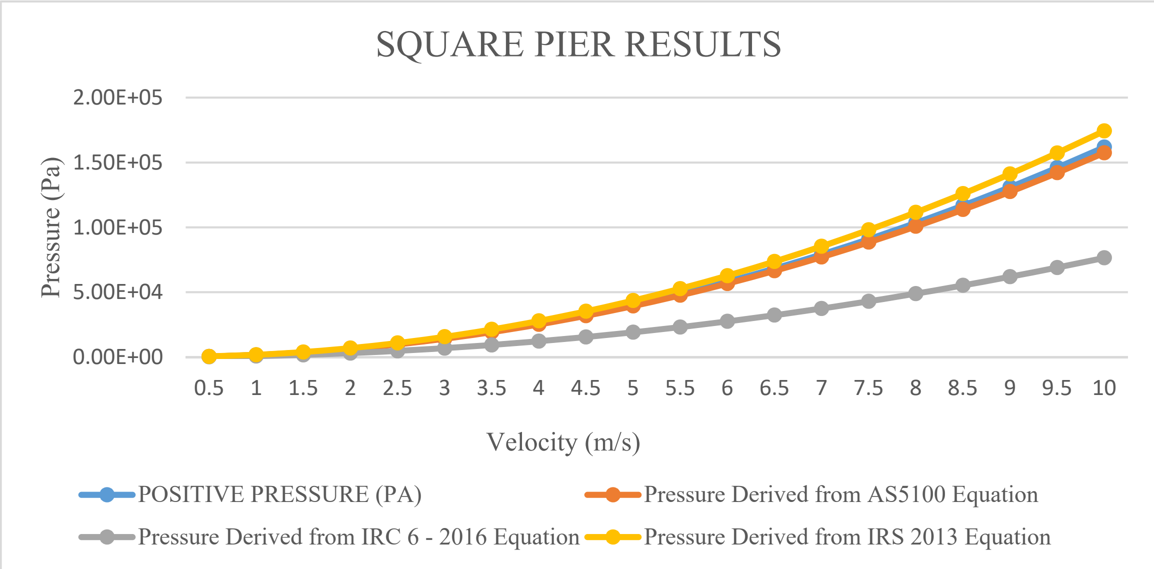


Figure (21): Comparison of square pier C.F.D. positive pressure results with various code equations

A C.F.D. simulation was used to derive pressures. The positive pressure obtained from a square pier is contrasted with the code AS5100: 2:2017 suggestions, I.R.C. 6: 2016 code and I.R.S.: 2013 code, as shown in Fig. 21. However, negative pressures on the square pier are more than positive pressures. Figure. 21 shows that for smaller speed as well as higher speed, the values of pressure are very close with the pressure values derived using the C.F.D technique. This shows close agreement with the results of standard equations. It demonstrates that, the square pier pressure compared with standard equations is conservative. It could be inferred that this square pier was analyzed using the C.F.D. calculation method represented in the standard equation which is conservative.

The results are compared utilizing design codes (AS 5100. 2 code), the Indian Road Congress for the Design of Highway Bridges Code (I.R.C. 6: 2016 code) and the Indian Railway Standard Design of the Sub-structure and Foundation of Railway. The results are based upon a specification for Australian Standard Code for Bridges.

Design specifications (I.R.S.: 2013 code) as shown in Figs. 17 and 21 show the comparative findings. The water flow pressure from AS5100:2 code is shown as the greatest one, while the second-largest result is obtained from the I.R.S. code and the most marginal result is derived from the I.R.C. code system. The results appear to be conservative in square shape when used in bridge design for the AS5100:2, I.R.S. and I.R.C. calculation processes.

CONCLUSIONS

C.F.D. is used to calculate bridge pier drag strength, form optimization and measure the active or passive damage. C.F.D. can help with many hydraulic problems. This case demonstrates the correct positive and negative pressures, reducing the time taken to implement an experimental method to assess the quantifiable properties of the pier for particular water system shapes.

From virtual investigation, the subsequent conclusions can be imitative for added exploration and real-world place. Following conclusions are drawn for future research and practical references.

1) A smooth and constant rate (excluding in uppermost and lowermost) curve is presented in the pressure dispersal on the square pier and the pier elevation. In contrast, the pressure distribution fluctuates in a circular pier.
2) The circular pier values are compatible with the square pier values (except at the top and bottom). They are close by a substantial variation in negative pressure on the supplementary side of the pier.
3) At higher flood velocity, the square shape area is under negative pressure. In contrast, at the reverse side of the subject, the circular shape area is marginal with erratic pressure distribution, illustrating how

the form has an integral impact on the water flow forces.

4) The total pressure on the pier is much minor compared to what code comparison implies when positive and negative pressures are combined.
5) The AS5100, I. R. C. 6, I. R. S. technique is ideal for a conservative calculation of the pressure of square cross-section. However, it has a harmful margin of protection for circular cross-section bridge piers and thus should be used cautiously.

This may be critical during design, since a localized failure may require pressure design, whereas structural strength might necessitate consideration of the resulting pressure in bridge piers. The united outcome of positive as well as negative pressure remains significant in structural design for structural strength. However, positive pressure must be considered in the design for localized destruction.

REFERENCES

Almasri, Amin, and Moqbel, Shadi. (2017). "Numerical evaluation of AASHTO drag force coefficients of water flow around bridge piers". Journal of Engineering Materials and Technology, 139, 021001-021008.

ASCE. (1994). "Minimum design loads for buildings and other structures". Vol. 7. American Society of Civil Engineers.

Ataei, Navid, and Padgetta Jamie, E. (2014). "Influential fluid-structure interaction modeling parameters on the response of bridges vulnerable to coastal storms". Structure and Infrastructure Engineering, 11 (3), 321-333.

Australian Standard 5100 (PART 2). (2017). "Bridge design". Standards Australia, Sydney, N.S.W.

Chung-Chan, Hung, Chung-Chan, and Wen-Gi, Yau. (2014). "Behavior of scoured bridge piers subjected to flood-induced loads". Engineering Structures, 241-250.

Coulbourne, William L., and ASCE PE, M. (2011). "ASCE 7-10: Changes to flood load provisions". Structures Congress, 1411-1417.

Du, Xiuli, Wang, Piguang, and Zhao, Mi, (2014). "Simplified formula of hydrodynamic pressure on circular bridge piers in the time domain". Ocean Engineering, 44-53.

Einstein, Hans Albert, and El-Sami, El-Sayed Ahmed. (1949). "Hydrodynamic forces on rough walls". Volume 2.

Fael, Cristina, Lança, Rui, and Cardoso, Antonio. (2016). "Effect of pier shape and pier alignment on the equilibrium scour depth at single piers". International Journal of Sediment Research, 1-7.

Fanga, Qinghe, Honga, Rongcan, Guoa, Anxin, Peter, K. Stansby, and Lia, Hui. (2018). "Analysis of hydrodynamic forces acting on submerged decks of coastal bridges under oblique wave action based on potential flow theory". Ocean Engineering, 242-252.

Fluent, A. (2011). "Ansys Fluent theory guide". ANSYS Inc., U.S.A.

Gaudio, Roberto, Tafarojnoruz, Ali, and Calomino, Francesco. (2012). "Combined flow-altering countermeasures against bridge pier scour". Journal of Hydraulic Research, 50 (1), 35-43.

Hamed, A.M., Vega, J., Liu, B., and Chamorro, L.P. (2017). "Flow around a semi-circular cylinder with passive flow control mechanisms". Experimental Fluids, 58, 22-32.

Hasan, Ihsan F. (2020). "Flood frequency analysis of annual maximum stream flows at selected rivers in Iraq". Jordan Journal of Civil Engineering, 14 (4).

Indian Railway Standard. (2013). "Code of practice for the design of sub-structures".

Indian Road Congress: 6. (2016). "Standard specifications and code of practice for road bridges section: ii loads and load combinations". (Seventh revision).

Kant Lakshmi, and Samanta Avik. (2020). "A review and comparative study of boundary conditions used for wave transmission in soil with application in free field response". Jordan Journal of Civil Engineering, 14 (4).

Liang Qiuhua, Chen Kai-Cui, Hou Jingming, Xiong Yan, Wang Gang, and Qiang Juan. (2016). "Hydrodynamic modeling of flow impact on structures under extreme flow conditions". Journal of Hydrodynamics, 28 (2), 267-274.

Liu Chengyin, Zhaoshuo Jiang, and Yu Haichang. (2019). “The safety analysis for bridge pier under nearby road construction and operation”. Measurement, 1-12.

Lukkunaprasit, and Lau Tze Liang. (2011). “The influence of bridge deck on tsunami loading on inland bridge piers”. The I.E.S. Journal-Part A: Civil & Structural Engineering, 4 (2) May, 115-121.

Mondal, R., Mandal, S., and Sahoo T. (2014). “Surface gravity wave interaction with circular flexible structures”. Ocean Engineering, 446-462.

Nasim, Maryam, Mohseni, Hessam, Setunge, Sujeeva, Zhou, Shiwei, and Dissanayake, Amila. (2017). “A comparison of the effect of pier shape on flood loading on bridges". Structural Conference, 1-10.

Nasim, Maryam, Setunge, Sujeeva, Zhou Shiwei, and Mohseni Hessam. (2018). “An investigation of water-flow pressure distribution on bridge piers under flood loading”. Structure and Infrastructure Engineering, 1-11.

Patankar, S. (1980). “Numerical heat transfer and fluid flow”. Boca Raton, FL: CRC Press.

Robelin, Charles-Antoine, and Madanat Samer. (2007). “Network-level reliability-based bridge inspection: Maintenance and replacement optimization model”. Jordan Journal of Civil Engineering, 1 (1).

Shu-xue, Liu, Yu-cheng, Li, and Guang-wei, Li. (2007). “Wave current forces on the pile group of base foundation for the East Sea bridge, China”. Ocean Engineering, 661-670.

Wang Piguang, Zhao Mi, Du Xiuli, and Cheng Xinglei. (2019). “A finite element solution of earthquake-induced hydrodynamic forces and wave forces on multiple circular cylinders”. Ocean Engineering, 1-11.

Wang, Yin-hui, Zou Yi-song, Xu Lue-qin, and Luo Zheng. (2015). “Analysis of water flow pressure on bridge piers considering the impact effect”. Mathematical Problems in Engineering, 1-8.

Yang Wanli, and Li Qiao. (2013). “The expanded Morison equation considering inner and outer water hydrodynamic pressure of hollow piers”. Ocean Engineering, 79-87.

Zhang, L. (2017). “Numerical simulation of flows past a circular and a square cylinder at high Reynolds number and a curved plate in the transitional flow”. MSc Thesis, Washington University in St. Louis.