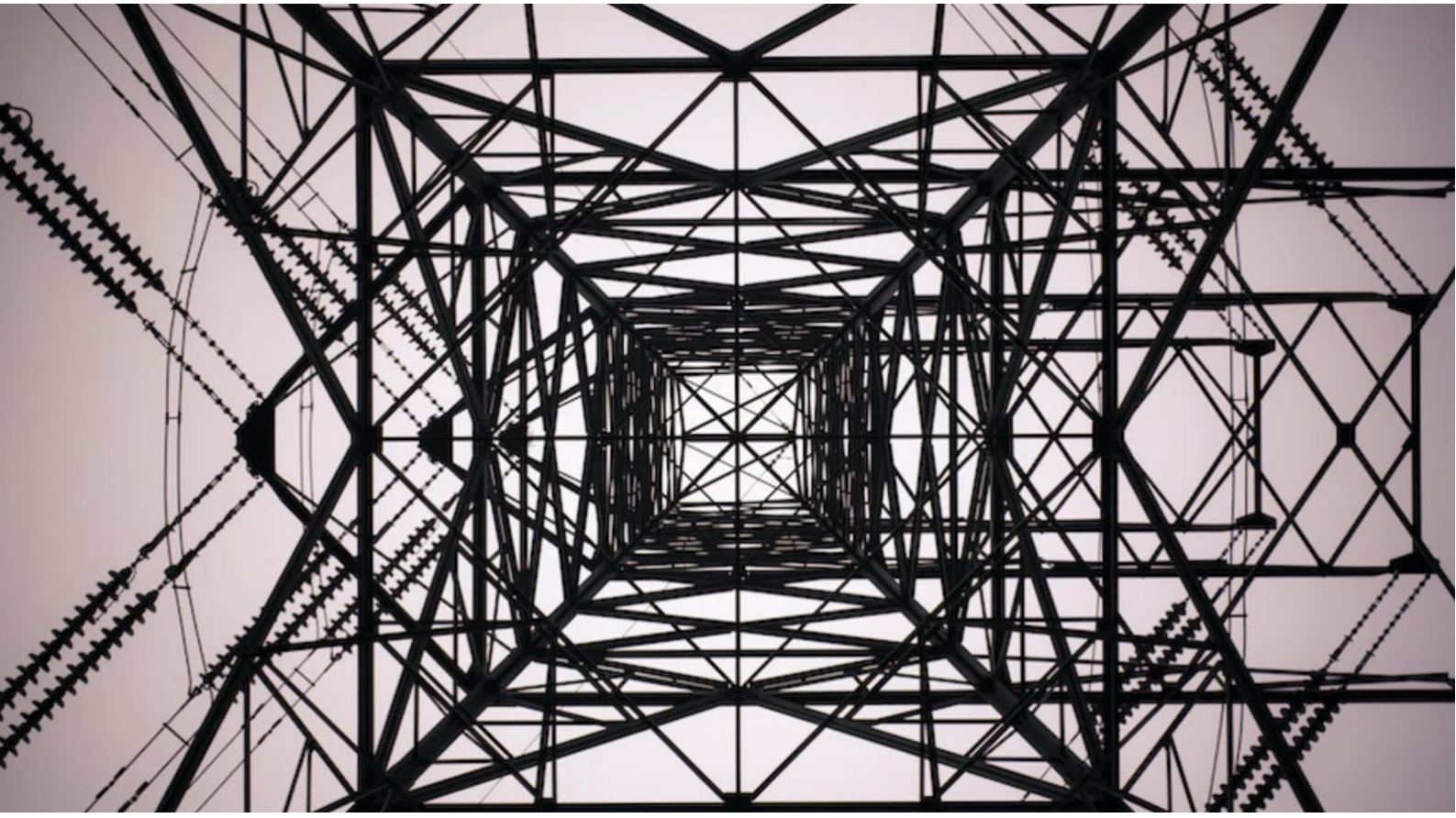
ISSN 2622-9374 (Online)

Asian Institute of Research

Engineering and Technology Quarterly Reviews

Vol. 5, No.2 December 2022



Asian Institute of Research
Connecting Scholars Worldwide

Asian Institute of Research
Engineering and Technology Quarterly Reviews
Vol.5, No.2 December 2022

Engineering and Technology
Quarterly Reviews
ISSN 2622-9374 (Online)

Engineering and Technology
Quarterly Reviews
ISSN 2622-9374 (Online)

The Asian Institute of Research
Engineering and Technology Quarterly Reviews
Vol.5, No.2, 2022: 1-17
ISSN 2622-9374

Infill Architecture: Contextualizing Design in An Urban Setting

Febrianta Rahmat[1], Nensi Golda Yuli[2], Ilya Fadjar Maharika[3]

[1] Magister of Architecture, Universitas Islam Indonesia, Gedung M Natsir, Kampus Terpadu UII, Sleman, Yogyakarta, Indonesia
[2] Department of Architecture, Universitas Islam Indonesia, Gedung M Natsir, Kampus Terpadu UII, Sleman, Yogyakarta, Indonesia
[3] Department, of Architecture, Universitas Islam Indonesia, Gedung M Natsir, Kampus Terpadu UII, Sleman, Yogyakarta, Indonesia

Correspondence: Nensi Golda Yuli. Email: nensi@uii.ac.id

Abstract
Contextuality is one of the main issues in urban architectural design. The addition of new non-context construction is likely to reduce the urbanized features. An infill design is needed as one of the maintenance strategies. This strategy is found to focus more on the heritage buildings unobserved in ordinary architecture. Therefore, this study aims to evaluate the contextualization of designs in an urban setting, using the infill architecture strategy. A semi-systematic literature review was used through the exploration of Google Scholar and ScienceDirect within the last five years, where 30 articles were found and analytically explored to determine the main elements and methods of infill architecture. The results showed that this strategy was based on material and details, form, scale, place, position, and usage. Besides the maintenance of contextuality, innovation was also observed through a creative combination of building elements and infill methods.

Keywords: Infill Architecture, Contextualism, Method, Elements

1. Introduction

Architectural contextuality is often a problem in urban area designs, due to being an approach to considering and responding to the situation and conditions of a specific location. This indicates that the building design is selectively connected to the cultural or physical context of the site. Furthermore, contextualism aims to create a unified dialogue of context components, concepts, and parts (Feisal, 2019). This is a reality every building needs to encounter when it occurs as a physical material, with the existing environment being considered a mediator of new designs (Ostanevics, 2017). Contextuality also emphasizes the ability of a building to seamlessly blend with its environment, as infill architecture is observed as one of the design strategies (Gaber and Akçay, 2020). Several previous studies have reportedly been carried out on this strategy, based on the application of infill at the building scale (Noorifard, Reza, and Mehdizadeh, 2020; Wang, Yang, Nyunn, and Azim, 2020). These focused on the

method of inserting new building components such as concrete and bricks, although did not essentially observe the regional context.

Despite the relationship of the present actual conditions to the application of infill on an urban scale, the consideration of area was still very crucial. This was due to its effect on the area contextuality and relationship to the infill process at the building scale. Some previous reports on an urban scale also explained the infill process in heritage building areas (Navickienė, 2017; Amirul, Zamri, and Abdullah, 2018; Parvizi, 2020), where the architectural strategy was observed based on the insertions of new designs, as well as elements and methods.

Until presently, most studies on an urban scale infill have highly focused on heritage area developments, with less evaluationofn ordinary building. This proves that subsequent studies are needed to analyze many essential elements and methods of infill architecture, despite the present reflection of ordinary buildings on the area and as a historical buffer. Therefore, this study aims to assess various appropriate infill elements and methods, to observe the regional context in ordinary buildings.

1.1. The History of Infill Architecture

The infill architecture approach was initially proposed by the Dutch architect, N.J. Habraken, in 1962, where the separation between the building structure (support), as well as the strategy in designing and constructing residential houses, were explained (Bukit, Hanan, and Wibowo, 2012). This perspective was then developed on a wider scale based on the inclusion of the approach in urban areas, which was initially developed in 1976 at the Second United Nations Conference on Human Settlements (Habitat II) and formally defined by American real estate in 1979 (Pormousavi, Naser, and Shokouhi, 2014). Moreover, the theory was subsequently developed (Brolin, 1980), which explained the importance of the regional contextuality elements due to strengthening the characteristical values of an area (Wirawan, 2014). In the historical context, the application of infill architecture realized some design criteria, including scale, material and detailing, landscape, view and landmark, historical development, as well as urban structure, grain, density, and mix. These are expected to be a guide for designers and policymakers in the process of inserting new buildings (Warren, 1998). In the urban heritage environment, the use of visual and spatial characters of building elements is applied as a criterion for the success of infill application to the context (Soosani, 2013). Despite this application obtaining a responsive design in public buildings, a bond is still needed to unify the new and old structures (Alfirevic and Simonovic, 2015). Additionally, a design guideline for urban planning has presently been developed by the development commission, among the infill implementation in regional planning (Dillon, 2021).

1.2. The Definition of Infill Architecture

Many reports have reportedly defined infill architecture and its various contexts since the 1980s, indicating the significance of these insertions in vacant and scattered locations (Schultz, Marilyn, and Vivian, 1984), or focusing on the construction of new housing, workplaces, shops, and other facilities within existing urban or suburban areas. These developments contained several types, such as design rehabilitation or expansion, vacant land building, and reuse of underutilized sites, e.g., parking lots and old industrial areas (Wheeler, 2002). Infill also occurs within a largely developed area, based on the improvement in built-up, established, developing, and existing developed sites surrounded by older growth (Listokin et al, 2006). From several definitions, infill development was often applied to underdeveloped land, including unsuitable buildings, due to the location component. In the function component, this process was residentially or non-residentially directed for reconstruction or reuse, even in historical buildings. Therefore, this report is expected to subsequently observe the embodiment of these definitions, regarding the developmental elements and methods used in infill architecture.

1.3. The Elements and Methods of Infill Architecture

Based on the experts' perspectives, filler architectural elements were used as design criteria in the contextual development process. This showed that the new filling process elements at the heritage design urban scale are building, function, height, orientation, material, color, surface, proportion, opening, shape, scale, linear, plane, enclosure, style, and order (Feisal, 2019). It also proved that functional visually related buildings should be harmonious regarding elevation, ceiling line, mass size, structure scale, facade treatment, finishing materials,

openings, colors, and boundaries (Al Hasany, 2018). Furthermore, the infill process needs to consider the materials and details of the surrounding buildings based on elements, such as colour, shape, structure, texture, and opening directions (Alfirevic and Simonovic, 2015). To appropriately understand the original condition of the area, the scale, position, and function of the surrounding buildings, archaeology, and the existing environmental structures should also be necessarily considered, respectively. This led to the consideration of three infill approaches (Alfirevic and Simonovic, 2015), namely (1) the mimesis approach, which reflects or imitates visual effects and other neighboring object characteristics, (2) the association approach, where the infill building adapts to the features of a location by transferring or projecting the characteristics of the surrounding designs, and (3) the contrast approach, which uses the infill development design method by denying part or all the characteristics of the surrounding environment. This leads to the visual deviation of the new object from the pattern of the surrounding buildings, due to the possession of a harmonious impression.

Despite having different terms, other several approaches still had specific similarities, including (1) the literal replication approach, which imitated existing elements or shapes, (2) the intervention approach, where a new element is added to the character. This aims to apply similar specifications without imitating the surrounding character, to protect their suitability in an urban context, (3) the abstract reference approach, where a reference was provided to the old environment, accompanied by the historical elimination of replication or work, and (4) the intention opposition approach, which deliberately provided a different form due to consciously conflicting the context (Feisal, 2019). The new additions to the old context affecting the physical and non-physical aspects, hence the accepted approaches are urbanism, architecture, and preservation strategies (Gharebaglou, Nejad, Ahad, and Ardabilchi, 2019). This shows that an urbanism approach focuses on sustainable development regarding land use and facilities, to meet user needs. The completion of new developments is also more emphasized by the architectural strategy, confirming that the initial option is to preserve the existing style, as well as fill in and use a contemporary and neutral modern pattern as a unified method. Meanwhile, the preservation approach is developed by preserving or improving social, economic, and architectural aspects.

2. Methods

A semi-systematic literature review was used in this study, with the initial stage utilizing the keyword- Infill Architecture- in Google Scholar and ScienceDirect. This was conducted with the subject area of engineering between 2015 to 2021. To explore the history and main theory of infill architecture development, some literature was observed before 2015. This method was adopted from the systematic literature review of an adaptation study (Table 1), with the involved nine steps shown in Figure 1.

Table 1: Proposed components of a systematic review

Components	Strategy
Study question/aims	1. The explicit aims and objectives of the review. 2. A clear description of the theoretical or conceptual approach used to guide the review.
Data source and document selection	1. The justification and description of the literature source, as well as the consideration of bias from the selection medium. 2. The description of criteria for inclusion and exclusion. 3. The documentation of included and excluded literature.
Analysis and presentation of results	B. The description of analytical methods. C. The critical appraisal of information quality.

(Source: Pearce et al., 2012)

In Table 1, the systematic review steps focused on the strategy to explore related literature and summarized the literature through a critical appraisal of information quality. However, Figure 1 explicitly showed the technical steps involved in the systematic review. This observed the identification, screening, and eligibility, and included steps as the filtering process to obtain related and appropriate literature.

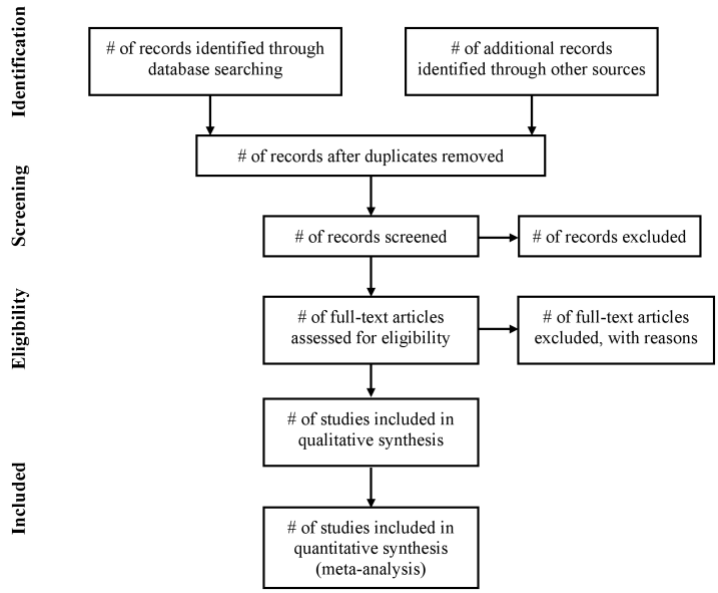


Figure 1: The flow of information through the different phases of a systematic review
(Source: Ansari and Moher, 2013)

This semi-systematic literature review method was designed in 5 stages while combining the Google Scholar and ScienceDirect exploration with basic theoretical concepts, as shown in Figure 2.

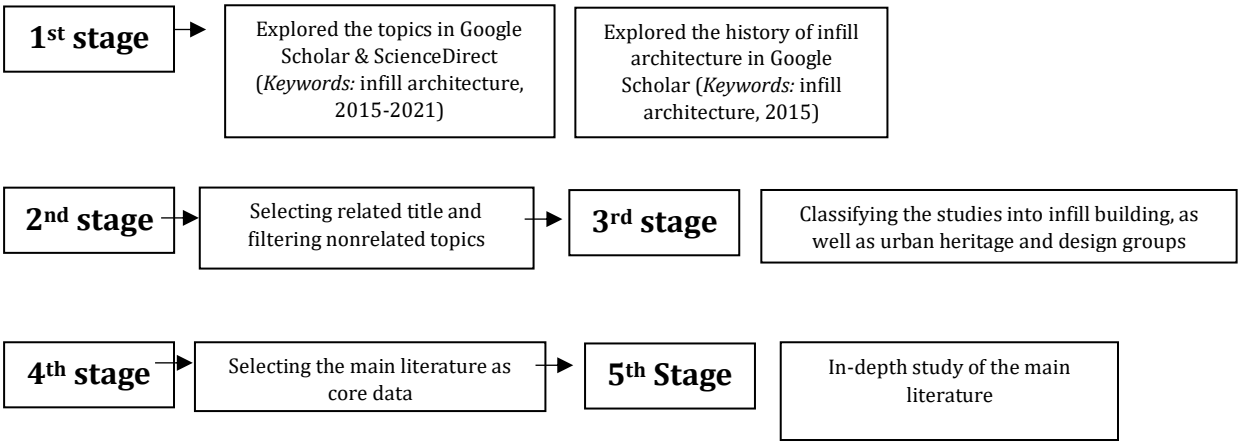


Figure 2: Study methodology

3. Results

Based on Figure 2, the first stage produced 16,400 and 58 articles through searches on Google Scholar and ScienceDirect, using the keyword and subject area, "Infill architecture and Engineering (2015-2021)", respectively. Meanwhile, 13 articles were obtained through Google Scholar regarding the searches related to the history of this theory before 2015, by directly referring to the author and/ or book title. In the second stage, the selection of titles through Google Scholar and ScienceDirect led to the acceptance of 16,400 and 58 articles, which were subsequently filtered for architectural studies to obtain 20 and 10 relevant studies, respectively.

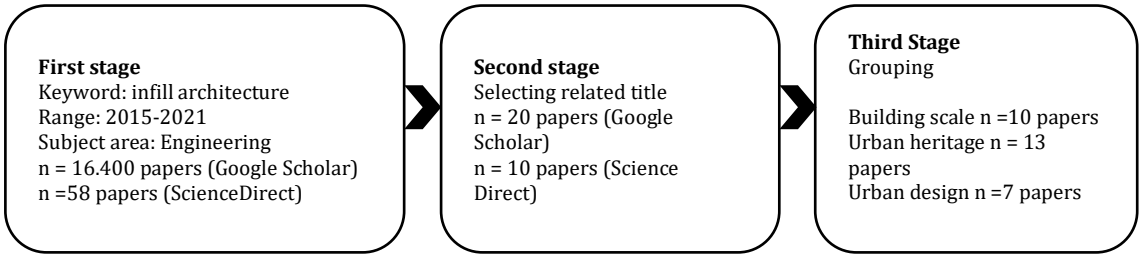


Figure 3: Article filtering for related infill architectural topic

According to the third stage, the obtained infill articles were grouped based on the building, as well as the urban heritage and general design scales, respectively. In this condition, the initial literature group highlighted those ten titles reviewed the application of infill at a building scale, with an analysis observed for the walls in structural modelling (Noorifard, Reza, and Mehdizadeh, 2020). Furthermore, the identification of Torsion was carried out in the final architectural design stage, by assessing the infilled frame in Chuan-dou. This is a traditional style widely found in rural China, with most of the partitions often utilizing wood as raw material (Tu et al, 2021). Another study analyzed the seismic behavior of the Chuan-dou frames filled with wood panels (Wang, Yang, Wang, and Iftikhar, 2021), to evaluate steel frames for infill walls. This subsequently explained the laboratory tests on two steel beam-to-column sub-assemblies with unsupported center column scenarios, namely truss (SF) and SLSW infill frame (IF).

Using 13 articles, the second group explained infill architecture at the urban heritage scale through specific evolution stages of conservation and heritage site development. This was subsequently carried out through the recommendations of new architectural elements, for integration into urban heritage sites (Navickienė, 2017). Besides this, other studies also focused on infill development theory by evaluating building structures and proposing a suitable design approach in heritage schools (Amirul, Zamri, and Abdullah, 2018). Despite these reports, subsequent architectural approaches were still analyzed with an interdisciplinary technique in an interactive framework, involving the architecture, urbanism, and restoration in Mashruteh Complex, Tabriz, Iran (Gharebaglou, Nejad, Ahad, and Ardabilchi, 2019). The interactive pattern of the filler design with legacy was also carried out by related infill studies (Feisal, 2019), with the main assessment based on the examples of the buildings inserted in heritage sites. Moreover, the third group contained seven articles presenting infill architecture results on a general urban design scale (Alfirevic and Simonovic S. 2015). This was carried out through the assessment of design ties among infilled buildings. It also observed the possibility of a filler approach through mimesis, association, and contrast techniques as new filling methods. One of the studies evaluating design guidelines which were conducted in Marion County, Indiana (Dillon, 2021). This described the guidelines for infill housing development, which were in line with adopted city policies such as smart growth, resilience, sustainability, and the use of existing infrastructure. For the urban facade variations, the combination of two architectural styles, sizes, scales, and openings, was observed as a reference for creating new building designs (Ali, 2021). Figure 4 shows the distribution of architectural infill topics from the obtained literature review.

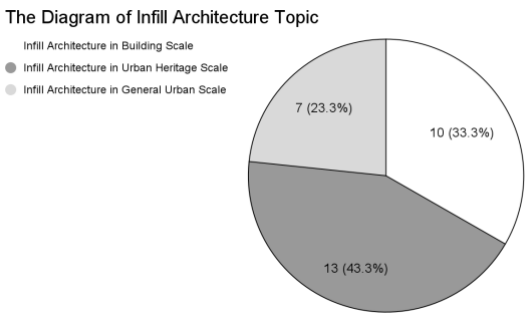


Figure 4: Infill architecture literatures findings diagram

In this condition, all thirty articles were used to analyze and classify the elements and method of infill architecture into three groups, namely building scale, as well as urban heritage and design.

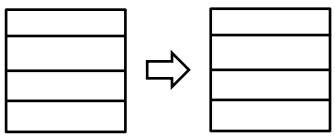
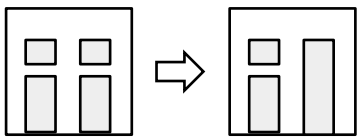
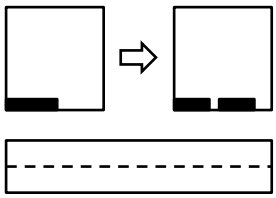
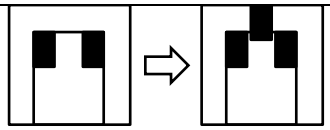
3.1. The Elements of Infill Architecture

Several experts explained the elements of infill architecture from a building to an urban scale, where the regional context was observed as an essential factor in determining the design basis for new developments. The following are the variables used to examine the elements of this architecture, based on the ordinary building urban scale.

3.1.1 Materials and details

These were used to observe some factors such as colour, texture, or material, in the application of infill architecture (Alfirevic and Simonovic, 2015). Besides that, openings/ air vents and decorations were also considered (Nasrollah, Ghafari, and Taheri, 2019). In a heritage environment, the use of different colors was often outstanding, although not easily applied in a general residential setting with numerous taste diversities. Despite the similar formation patterns, the use of textures led to identical and different results in the heritage and ordinary buildings, respectively. For the openings and decorations on doors, windows, and air vents, all elements should also match the context of both environments. This is because the opening has a direct effect on the appearance of the building, which subsequently influences the design structure. Meanwhile, the direction of the building should be on the main axis of the road due to being related to regional activities, with this specific infrastructure being the central circulation (Table 2).

Table 2: Infill architecture guidelines on materials and details

Colour	
Texture	
Opening	
Direction context	
Decoration	

3.1.2 Form

Heritage buildings have a strong character based on architectural details, where the application of infill design needs to observe the shape or style of the surrounding environments, to provide insight and input on new installations (Nasrollah, Ghafari, and Taheri, 2019). This was in line with the pattern of blocks, roads, and surrounding environments, with the public building styles experiencing difficulties in supporting the similarities. However, it was observed from the composition of the building mass, such as the height and size of the design. The bonding of the new building roof shape to the old type should also be considered due to influencing the skyline of the area (Alfirevic and Simonovic, 2015).

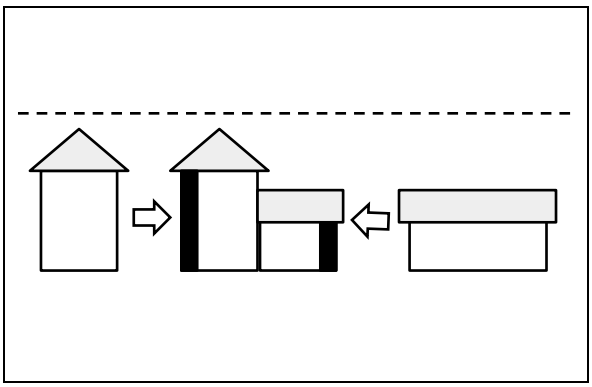


Figure 5: Elements of style and the influence of skylines in urban context

3.1.3 Scale

In applying infill architecture on an urban heritage scale, the consideration of the scale and hierarchy of new buildings to the surrounding environments was very essential (Nasrollah, Ghafari, and Taheri, 2019). This indicated that the architectural elements in ordinary buildings were subsequently observed by assessing the building frame related to the height and size of the surrounding structures (Figure 6). The application of new scale was also applied to the harmony and sustainability of the buildings within the area. This led to the new building being scaled according to the surrounding structures (Alfirevic and Simonovic, 2015).

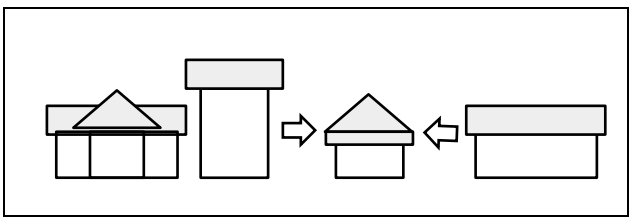


Figure 6: New building scale context to the old structures

3.1.4 Placement position

This is the placement of new buildings in the area affecting the visual space, with considerations necessarily needed on the mass pattern of old structures (Nasrollah, Ghafari, and Taheri, 2019). It also has similarities to the building direction, by extending the surface of the surrounding environment facade to the new ones (Alfirevic and Simonovic, 2015). Meanwhile, the placement of new buildings in the public areas is positioned according to that of the existing surrounding structures. In these areas, the implementation of new buildings was carried out by adjusting the boundaries and considering the open spaces. This indicated that the building placement needs to also consider the archaeology of the area (see Figure 7).

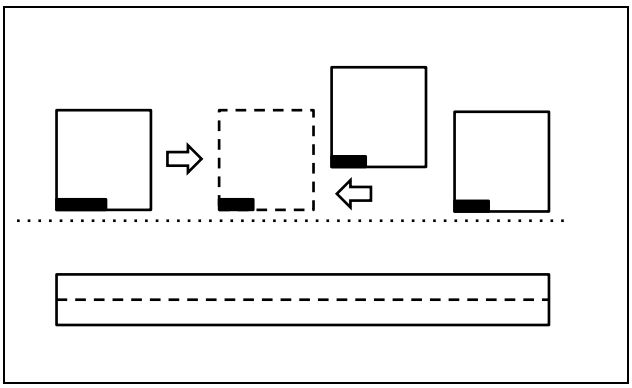


Figure 7: The setting of the new building in the urban context

3.1.5 Use

In urban heritage, the building's functional elements contained cultural, social, economic, and political functions (Nasrollah, Ghafari, and Taheri, 2019). This affected the typology as regards its position, based on a public building. The form of the residential opening function was also different from that of a shop (Figure 8), indicating that new buildings need to consider the typology of the surrounding essentiality.

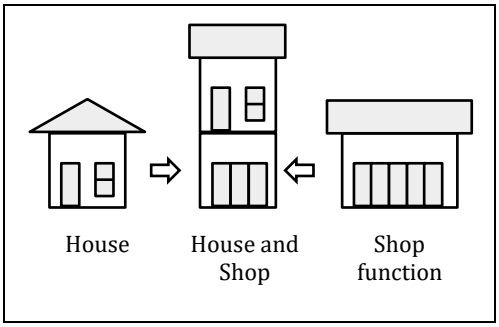


Figure 8: Building function context

3.2. The Methods of Infill Architecture

Based on the experts' proposal, the following are the infill architecture methods adopted for ordinary building applications. Subsequently, these were applied in combination of heritage and ordinary buildings. The result was a review of the method to be used in ordinary buildings, with two techniques being grouped from the 2 main literature, for instance, Alfirevic and Simonovic (2015) and Feisal (2019). The initial method was the contextual technique, containing the mimesis, association, literal replication, invention, and abstract reference approaches. Meanwhile, the second method was the non-contextual approach, containing the contrast and intention opposition techniques.

3.2.1 The mimesis and the literal replication approaches

The mimesis approach is often used in infill architecture, imitating the visual characteristics of neighboring objects (Alfirevic and Simonovic, 2015). This indicates that new buildings need to apply existing visual elements to surrounding structures, due to the imitation of paint colors, materials, textures, openings, and directions, as well as decorations. Therefore, the new building is expected to have similar architectural elements as the neighboring design. Using the literal replication approach for heritage buildings, similar results are still observed through the imitation of existing elements or forms (Figure 9). This is mostly applied to heritage buildings due to having high similarities to the mimesis method. In ordinary buildings, the application of this method is used by imitating the roof shape, opening, colour, and texture from an existing building to a new one. This confirms that the new building is expected to have similar visual elements to the old building.

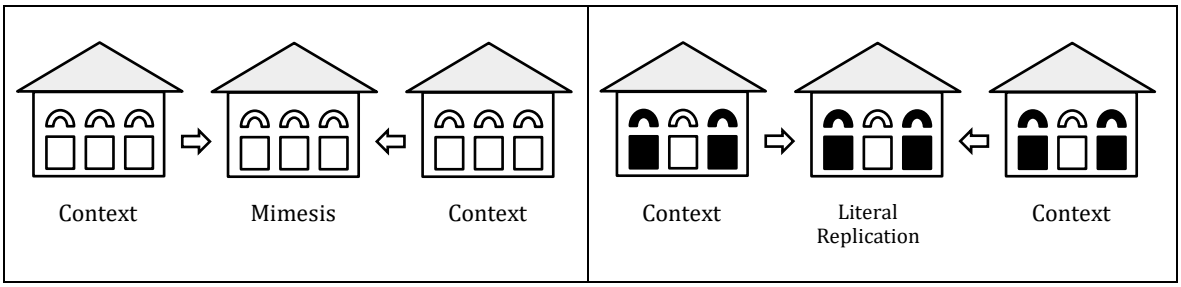


Figure 9: Mimesis and literal replication approaches

3.2.2 The association and the invention approaches

The association method often emphasizes or reinforces the existing surrounding architectural elements, by transposing the characters from neighboring objects to produce uniform design features (Alfirevic and Simonovic, 2015). In the urban heritage, the use of a similar structural style as local architecture is the leading choice in inserting new buildings, which is often carried out through the incorporation of modern contemporary elements. However, modern buildings need to adapt to the existing designs, with the new installation expected to emphasize the elements of the surrounding building style. The application of the invention is also carried out with innovations, due to intervening with similar or related styles. In this method, a new element is often added to the character, to implement similar specifications without imitating the surrounding surfaces (Feisal, 2019). For ordinary buildings, the application in urban areas is conducted through the determination of a surrounding architectural style in the surrounding architecture. Subsequently, the new building is observed to apply the results of a unique style to the existing character (Figure 10). This confirms that the realization of a new technique is expected, although with a similar character as the existing context.

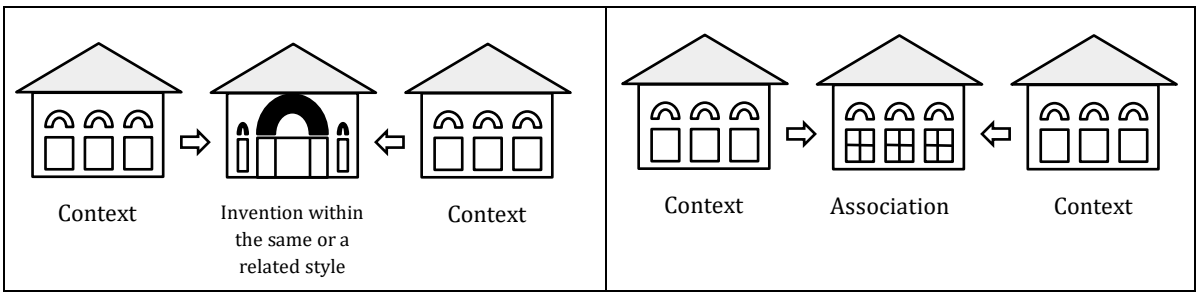


Figure 10: The association and the invention approaches within the same or related style

3.2.3 The Abstract reference

In this approach, the implementation of infill is often disguised, due to being similar to the historical environment while eliminating replication with the existing old style. This was operated by reducing the composite to an abstract form. Based on the facade, the colors, materials, and textures of the elements were found to imitate context, with the shape using a modern style to reflect a blend of styles (Figure 11). However, the shape and the materials of the building used contextual characteristics and modern elements, including glass, respectively (Feisal, 2019). This proves that the designer's imaginative work is expected to maintain context with varied styles.

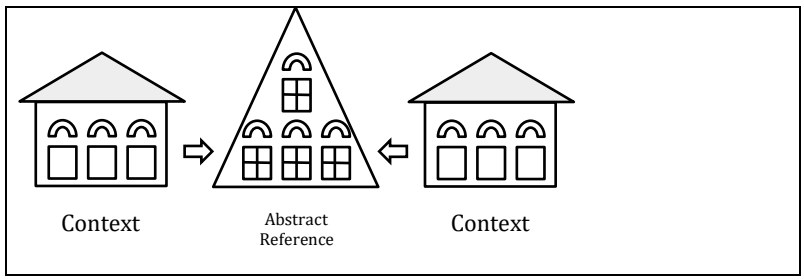


Figure 11: Application of the abstract reference approach to the building style

3.2.4 The contrast and intention opposition approaches

According to the contrasting approach, the new building is often different from the existing type, due to being strikingly different from the regional context (Figure 12). Meanwhile, the juxtaposition of two different styles is emphasized in this method. This highlights that the architecture of the new building is considered to represent the era of construction, with intensive care being recommended when using this approach (Alfirevic and Simonovic, 2015). The intention opposition method also has similarities with the contrast approach, due to being intentionally conducted to provide a different shape. Despite being a conscious counter approach, it is still observed to change the contextual character of the region, regarding the achievement of unity through independent ideas (Feisal, 2019).

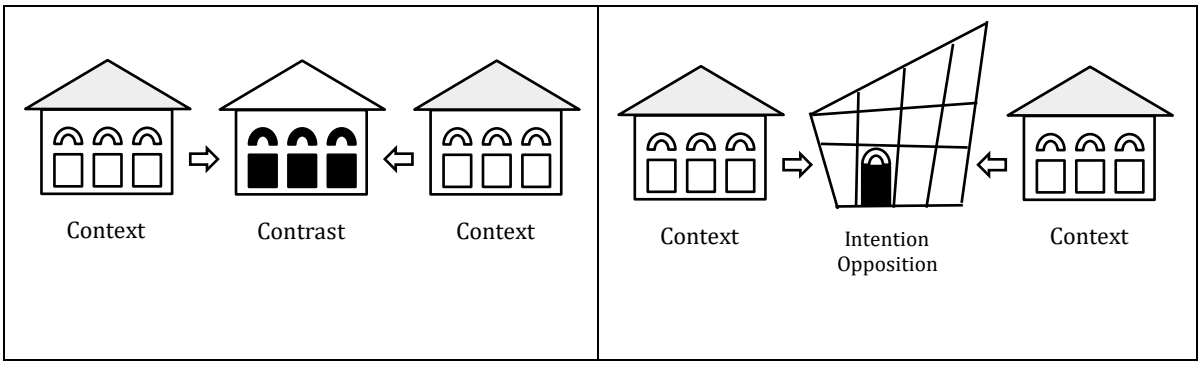


Figure 12: Application of the contrast and the intention opposition approach

From these reviews, the simple observations on recent infill architecture studies, especially in ordinary building contexts, are shown in Figure 13.

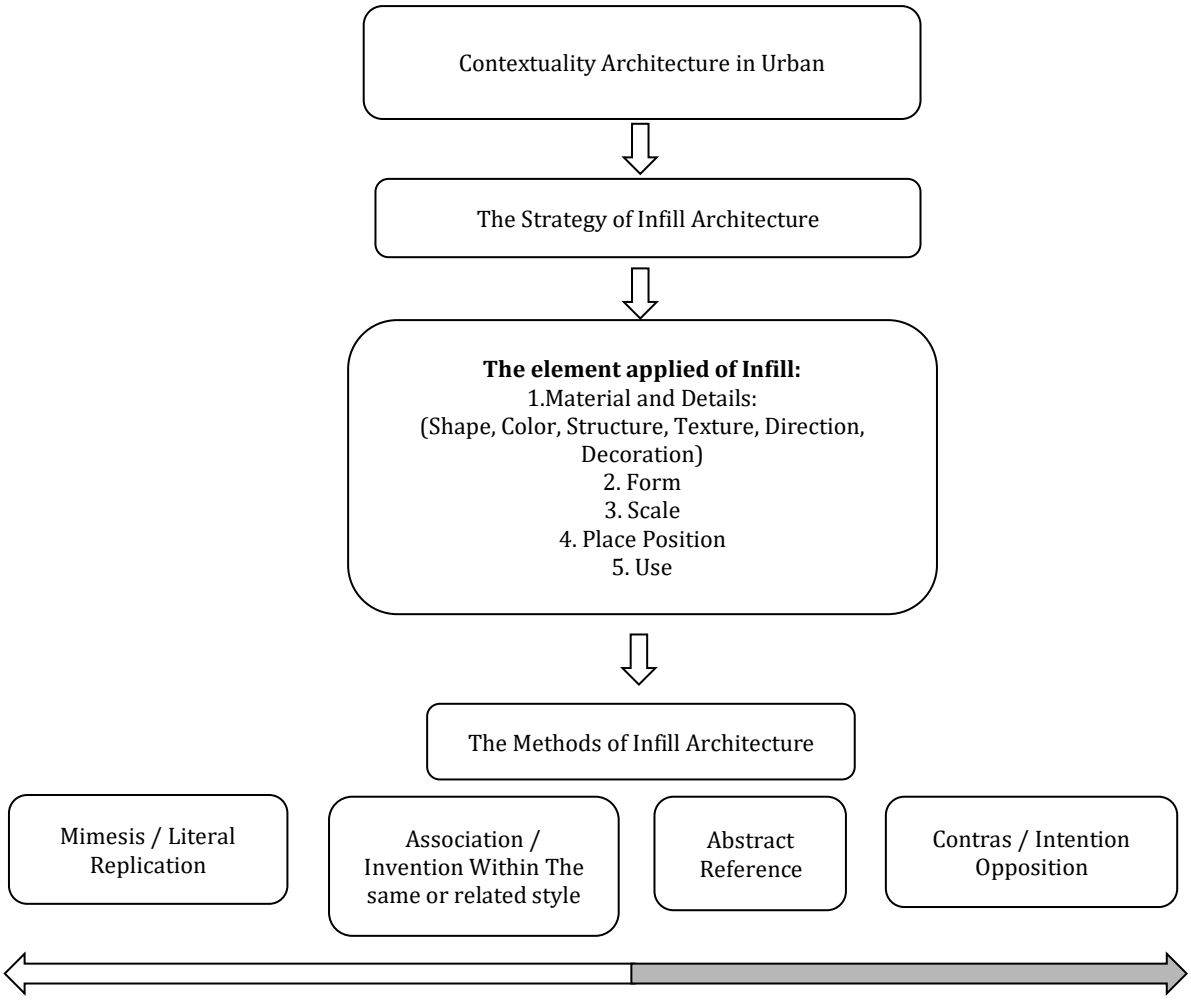


Figure 13: Infill architecture approach problem scheme

4. Discussion

4.1. Infill Architecture Application in Richmond Riverside, London

Based on this report, Richmond Riverside, London was observed to be using mimesis and literal replication approach, where the repetition of similar new building shapes was found by Erith & Terry (Soosani, 2013). In this condition, the new building applied the classic elements used by the old design. This showed that the scale of the new building was imitated as observed from the area's skyline.

Figure 14. Richmond Riverside, London
Source: richmondriverside.com

The placement of the building was also parallel to the old type, with river and road borders observed at the front. On the windows, the clear vertical components of the building and the decorative lattice elements subsequently imitated the surrounding characteristics. Using similar paint colors as the neighbors, the new building was observed to be very similar to its surroundings. The application of the approach list is shown in Table 3.

Table 3: Infill Architecture in Richmond Riverside Building, London

Elements	**Existing Context**	**Infill Architecture**	**Contextual ● Non – Contextual ○**
Material and details			
Colour	Orange and white	White	●
Structure	A firm vertical and horizontal components in the opening	A firm vertical and horizontal components in the opening	●
Texture	Painted wall	Painted wall	●
Direction	The building leads to the road and river view	The building leads to the road and river view	●
Decoration	Window grilles and molding elements	Window grilles and molding elements	●
Form	Simple rectangular shape with classic British style and sloping roof.	Simple rectangular shape with classic British style and sloping roof.	●
Scale	Three floors building mass	Three floors building mass	●
Place Position	Existing buildings have river and road borders	Existing buildings have river and road borders	●
Use	Office building	Apartment	●
Summary: 9/9 infill design elements lead to a mimetic or literal replication approach with copying an existing caracter			

4.2. Infill Architecture Aplication in Al Azhar Chiefdom, Cairo

For the association and invention approaches, Al Azhar Chiefdom, Cairo was used as an example. This indicated that the application of a similar specification was carried out at this building in 1990, without imitating the surrounding objects (Feisal, 2019). Incorporating the basic hexagon shape, the new building was different from the rectangular symbol of the existing structure (Figure 15).

Figure 15: Al Azhar Chiefdom, Cairo.
Source: alhamd.com, 2018

However, the typical Arabic building style used on each side blended the new design with the old one. The use of decorative arches and circles was also different from the surroundings, although the square frame was a binding element for two distinguished elements. In this condition, the other infill design elements were the use of the surrounding context, such as the bright beige colour used for the existing building. The application of the approach list is shown in Table 4.

Table 4: Infill Architecture in Al Azhar Chiefdom, Cairo

Elements	Existing Context	Infill Architectural	Contextual ● Non – Contextual ○
Material and Details: Colour	Bright cream	Bright cream	●
Structure	The horizontal and vertical components as a large mass and fill, respectively	The horizontal and vertical components as a large mass and fill, respectively	●
Texture	Plaster wall	Plaster wall	●
Direction	The building leads to the main road at the front	The new building is in front of the old building and leads to the main road	●
Decoration	Simple square shape	Arch and circle shapes with square frames	●○
Form	Simple rectangular shape with an Arabic building style	A hexagon base with Arabic characteristics on each side	●○
Scale	Multistory building in 6 to 7 floors	Lower and parented to the old building	●
Place Position	Symmetrically parallel to the road ahead	On the axis of the old building and the road ahead	●
Use	School building	School building	●
Summary: 2/9 infill design elements lead to the association/invention approaches, 2 new model elements with the same or related styles			

4.3. Infill Architecture Aplication in The Memorial Park Soekarno, Blitar, Indonesia

The Memorial Park Soekarno, Blitar, Indonesia used the abstract reference approach and was developed in 2007 by architects, Widodo & Baskoro Tedjo. This was referenced as an old building with the consideration of being removed for the designation of new buildings. Its location was also in the middle of an urban settlement and observed as a Joglo, a characteristic of traditional Javanese houses. The new building observed as a modern cube covered with exposed natural stone, hence the shape of the temple was stated to have a wider historical context (Wirawan, 2014). This explained that the use of natural stone material, black color, caused a contrast to the surrounding buildings (Figure 16).

Figure 16: Map and New Building Soekarno Memorial Park, Blitar, Indonesia
Source: Google Earth and Ferdiansyah, 2022

This different strategy was impacted the new building as the background of the existing one, which is still observed as the focus of the site. Despite having a height of 2 floors, the new building was still lower than the existing Joglo. This was due to the location of the old building at a contour height (Figure 16). Subsequent details on the implementation of this approach are shown in Table 5.

Table 5: Infill Architecture in Soekarno Memorial Park

Elements	Existing Context	Infill Architectural	Contextual ● Non – Contextual ○
Material and Details: Colour	Brown	Black	○
Structure	Pyramid/ header vertical components	Concrete with a cube composition	○
Texture	Wood and natural effect	Natural stone and effect	●○
Direction	At the back of the site and leads to the regional road	The entry point on the front leads to the main road	●
Decoration	Decorative carvings on the pillars and building poles	Decoration as exposed natural stone and relief garden walls	●○
Form	Joglo shape with a vertical roof is a characteristic of traditional Indonesian houses	A simple square shape with a flat roof wrapped in natural stone, resembling a temple with the characteristics of cultural Indonesian sites	●○
Scale	The one-story building has a high canopy roof	A two-story building with a flat roof, although lower due to contour difference	●○
Place Position	Located in the middle of the back area	Located in the middle of the front area	●
Use	Graveyard	Museum	●○
Summary: 5/9 infill design elements lead to an abstract reference approach that can be contextual and non contextual, 2 elements are non contextual			

4.4. Infill Architecture Aplication in Royal Ontarium Museum, Canada

In contrast/ intention opposition approach, Royal Ontarium Museum, Canada is observed as an example. The original building and the outhouse, The Crystal, were developed in 1912 and 2007, respectively, by Daniel Libeskind (Hume, 2014). In this approach, additional buildings did not visually consider the historical contextual values, as well as other structures and locations, for the new design to be different from the existing one (Alfirevic and Simonovic, 2015). Therefore, the contrasting approach at the Royal Ontario Museum was highly utilized in the juxtaposition of two architectural styles representing its era (Figure 17).

Figure 17: Royal Ontario Museum, Canada
Source: Sokolov, 2021 and mapio.net, 2021

In this condition, the difference between the new building based on its iconic character added to the attractiveness of the environment and the old structure. The infill elements causing the context were also the direction of the opening that led to the main road in the neighborhood, with the silver color of the new building blending with the

grey natural grey paint of the old structure. The contrast/ intention opposition approach is also summarized in Table 6.

Table 6: Infill Architecture in The Crystal of Royal Ontario Museum

Elements	**Existing Context**	**Infill Architectural**	**Contextual ● Non – Contextual ○**
Material and Details:			
Colour	Grey	Silver	●○
Structure	Firm vertical and horizontal components of the opening	Dynamic components with triangular and parallelogram shapes	○
Texture	Brick	Glass and aluminum	○
Direction	The building leads to the road	The building leads to the road	●
Decoration	Arch element in the opening	Aluminum glass frame and building envelope	○
Form	Old building with classic Italian and Neo-Roman style	New building with a contemporary style	○
Scale	Elongated building with a height of 2 floors	More than two floors, with prominent vertical elements	○
Place Position	Existing buildings are regularly spaced and parallel to the road	The new building has a more protruding section towards the road at the top.	○
Use	Museum	Museum	●
Summary: 6/9 infill design elements lead to a contrasting approach or intention opposition, with 3 elements for contextualization bond			

5. Conclusion

Considering the various analyzed and evaluated methods and elements, future contextuality-based development or planning should utilize the infill architecture approach, which is carried out at the micro-scale of buildings and the urban scale. This indicated the infill application observed contextuality as an inconsiderable and considerable factor that should be preserved, based on the perspectives of a building and urban scale. According to the reviewed literature, most of the approaches were suitable for use in historical preservation areas with heritage buildings. However, a more general application with ordinary buildings in contextuality areas was used through local infill elements. In analyzing location contextuality, the suitable elements were also material and details, form, scale, place position, and use. Besides this, the infill application strategy also had various approaches, ranging from the methods intentionally similar to local architectural conditions (mimesis) to those deliberately different with contextuality maintenance (contrast).

Acknowledgments

We would like to thank the Magister of Architecture, Department of Architecture, Universitas Islam Indonesia, for the support in completing this paper.

References

Al Hasany, M. (2018). Urban Infill Processes and Their Role in Achieving the Main Objectives within the Old Urban Fabric, *Journal of Engineering and Architecture*, 6(2), pp. 20–31. doi: 10.15640/jea.v6n3.

Alfirevic, D. & Simonovic S. (2015). Infill architecture: Design approaches for in-between buildings and "bond" as integrative element, *Arhitektura i urbanizam*, (41), pp. 24–39. doi: 10.5937/a-u0-8293.

Alhamd.com. (2018). *alhamd.com*. Retrieved from https://alhamd.com.eg/project/al-azhar-chiefdom/

Ali, A. K. (2021). Facade Style Mixing using Artificial Intelligence for Urban Infill, Preprint 2021(April), pp. 1–10. doi: 10.20944/preprints202104.0690.v1.

Amirul, M., Zamri, H. & Abdullah, J. (2018). Evaluation of infill building block in heritage schools in Kuala Lumpur, 16(3), *Journal of The Malaysian Institute of Planners* 16 Issue 3 (2018) pp. 83–96.

Ansari, M. T., & Moher, D. (2013). Systematic reviews deserve more credit than they get. *Nature Medicine*, *19*(4), 395–396. https://doi.org/10.1038/NM.3151

Brolin C, Brent .(1980). Architecture in context : Fitting New Buildings with Old, Van Nostrand Reinhold, New York.

Bukit, E. S., Hanan, H. and Wibowo, A. S. (2012). Aplikasi Metoda dari N. J Habraken dalam Studi Transformasi [The Application of Method from N. J. Habraken in Transformation Study], *Jurnal Lingkungan Binaan Indonesia V*, 1(1), pp. 51–62.

Dillon, J. (2021). Infill Housing Guidelines, Metropolitan Development Commission of Marion County, Indina

Feisal, Z. (2019). Infill Design Heritage Sites Study of Experts' Preferences and Attitudes. *Journal of Engineering and Applied Science*, 451-463 .

Ferdiansyah, T. F. (2022). *Earth Google*. Retrieved from https://earth.google.com/web/search/memorial+park+soekarno

Gaber, M. A. & Akçay, A. Ö. (2020). Qualitative and Quantitative Evaluation Techniques of New Infill Designs in Historic Context. *Revista Amazonia Investiga*, 9(35), pp. 20–33. doi: 10.34069/ai/2020.35.11.2.

Gharebaglou, M., Nejad E., Ahad & Ardabilchi, I. (2019). Infill Architecture: An Interdisciplinary Approach to the Design of Historic Context: Case Study: Mashruteh Complex in the Historic Bazaar of Tabriz, Iran, *Bagh-e Nazar*, 16(76), pp. 57–68. doi: 10.22034/bagh.2019.142666.3713.

Google.Earth. (2022). Retrieved from https://earth.google.com/web/search/memorial+park+soekarno/@-8.08536295,112.1763276,197.15902775a,893.49200522d,35y,-0h,0t,0r/data=CigiJgokCev2pJF1GTJAEef2pJF1GTLAGQ350q2rdDFAIXHoHf_6MVTA

Hume, C. (2014, March 21). Toronto Star. Retrieved from How the Royal Ontario Museum represents 100 years of architecture: https://www.thestar.com/entertainment/2014/03/14/how_the_royal_ontario_museum_represents_100_years_of_architecture.html

Listokin, D., Walker, C., Ewing, R., Cuddy, M. & Cander, A. (2006). Infill development Standards and Policy Guide Retrieved from ttps://www.nj.gov/dca/divisions/codes/alerts/pdfs/2006_6_rev2007_4_infill_dev_stds.pdf

Mapio.net. (2021). *mapio.net*. Retrieved from https://mapio.net/pic/p-7126950/

Noorifard, A. Reza, M. &, Mehdizadeh, F. (2020). An approximate method to identify torsion caused by infill walls through geometric specifications of architectural plans. *Journal of Building Engineering*, Volume 32.

Navickienė, E. (2017). Infill Architecture: Chasing Changes of Attitudes in Conservation of Urban Infill Architecture: Chasing Changes of Attitudes in Conservation of Urban Heritage. Proceeding of the 3rd International Conference on Heritage and Sustainable Development at Porto: Portugal, Vol. Heritage 2012. Barcelon: Green Lines Institute, 2011. ISBN 9789899567153

Nasrollah Beiglu, F. B., Husseini Ghafari, S. M. & Taheri, A. (2019). Infill Architecture as a Solution for Livability and Historical Texture Quality Promotion. *Civil Engineering Journal*, 5(1), p. 165. doi: 10.28991/cej-2019-03091234.

Parvizi, E. (2020). Collective Memory as a Measure to Evaluate the Infill Architecture Innovations in Historic Contexts (Case Study: Historic Context of Imam Zadeh Yahya in Tehran). *Iran University of Science & Technology*, 30(June), pp. 66–75. doi: 10.22068/ijaup.30.1.66.

Pearce, T., Ford, J. D., Caron, A., & Kudlak, B. P. (2012). Climate change adaptation planning in remote, resource-dependent communities: An Arctic example. *Regional Environmental Change*, *12*(4), 825–837. https://doi.org/10.1007/S10113-012-0297-2

Pormousavi, S., Naser Mostofi, A. & Shokouhi Bidhandi, M. (2014). Recognizing The Rudiments and Administrative Strategies of Inter-Escalation Development of Tehran City as a Dimention of Sustainable Urban Development. *Journal of Iranian Social Development Studies (JISD)*, 6(4 (24)), 37-57. https://www.sid.ir/en/journal/ViewPaper.aspx?id=448099

Richmondriverside.com

Soosani, L. (2013). Questioning the compatibility of the infill architecture in historic environment, case study: walled city of Nicosia. Master Thesis (July). Available at: http://i-rep.emu.edu.tr:8080/xmlui/handle/11129/1346.

Schultz, Marilyn S, & Vivian L. (1984). Encyclopedia of community planning and environmental management. New York, NY: Facts on File Publications.

Sokolov, M. (2021, October 22). *Wikipedia*. Retrieved from File Royal Ontario Museum: https://en.wikipedia.org/wiki/File:Royal_Ontario_Museum_in_Fall_2021.jpg

Tu, L. & Cui, Z., Xu, M., Feng, Y. & Li, T. (2021). Experimental study of traditional Chuan-dou frames infilled with wood panels under in-plane cyclic load. *Journal of Building Engineering,* Volume 43.

Wang, F., Yang, J. & Nyunn, S. & Azim, I. (2020). Effect of concrete infill walls on the progressive collapse performance of precast concrete framed substructures, *Journal of Building Engineering*, Volume 32.

Wang, F., Yang, J., Wang, X. & Iftikhar, A. (2021). Study on progressive collapse behavior of steel-framed substructures with sheathed CFS stud infill walls, *Journal of Building Engineering*.

Warren, John (1998). Context: New Building in Historic Setting, The Architectural Press, London.

Wirawan, I. M. Y. (2014). Aplikasi Konsep Arsitektur Infill pada Museum di Kawasan Bersejarah di Banjarmasin, Studi Kasus Memorial Park Soekarno, Blitar dan Monumen Nasional, Jakarta [The Application of Infill Architecture Concept in Museum Building at Heritage Area in Banjarmasin. Case Study: Soekarno Memorial Park, Blitar and National Museum, Jakarta], *E-Journal Graduate Unpar Part D-Architecture*, 1(2), pp. 213–220.

Wheeler, Stephen M. (2002). Smart infill: Creating more livable communities in the Bay Area: A guide for Bay Area leaders. San Francisco, CA: Greenbelt Alliance. Spring. http://www.Greenbelt.org/downloads/resources/reportsmartinfill.pdf

.

ASIAN INSTITUTE OF RESEARCH
Connecting Scholars Worldwide

The Asian Institute of Research
Engineering and Technology Quarterly Reviews
Vol.5, No.2, 2022: 18-29
ISSN 2622-9374

Numerical Analysis of Frictional Drag Reduction of Watercraft Using Water Lubrication Technique

Atilla Uygar Sönmez[1], Vijayan S. N.[2]

[1]Department of Mechanical Engineering, Faculty of Engineering, Gaziantep University, Gaziantep, Turkey
[2]Assistant Professor, Department of Mechanical Engineering, Karpagam Institute of Technology, Coimbatore, Tamil Nadu, India.

Correspondence: Atilla Uygar Sönmez. Email: atillasonmez2009@gmail.com

Abstract
The majority of the energy expended by watercraft is used to overcome drag. Frictional resistance can account for up to 80 % of overall resistance, especially on large vessels, which leads to an increase the fuel consumption and environmental impacts. As a result, finding strategies to reduce frictional drag is interesting. There are numerous strategies for reducing drag that have already been proposed that are air lubrication techniques, boundary layer energizing, and suction is few of the examples. This study proposes a new way of reducing drag this method is known as water lubrication. To create adverse flow, water jets are used to split the flow. The formation of an auspicious boundary layer ore sluggish boundary layer surrounding the surface it reduces drag significantly. Separation is generally undesired since it expands the wake zone and as a result it produces drags. In flat plate separation it does not significantly enlarge the wake region. Separations form a slow or adversely directed layer on the flat plate if they are created and positioned correctly. This is demonstrated in this study through the use of ANSYS Fluent simulation. Also, with water jet velocities of 3 to 15 m/s drag reductions of 17 % to 134 % have been achieved.

Keywords: Watercraft, Friction, Drag Reduction, Water Jet, Flow, ANSYS

1. Introduction

When an object moves in a fluid the fluid exerts forces against the object in the flow direction, that force is called Drag. Drag is extremely important for moving objects because it is a force that moving objects must overcome. If a watercraft wants to go speed (V) against drag (D) must have D*V power. The needed power must be proportional to the drag or the required energy is equal to force time distance. Most of the transportation cost comes from drag. Spending higher amounts of energy (fuel) do not only mean losing money but also causes environmental pollution because of carbon emissions from spent fuel. When an object moves through fluids on its surfaces, pressure builds up and shear stresses are distributed. Pressure forces are perpendicular to the surface and friction forces are tangent to the surface.

Total surface integration of these forces gives total acting force (TF). Lift occurs when the flow component of the TF is perpendicular to the flow component, and drag occurs when the flow component of the TF is parallel to the flow component. The forces generated from the fluid are shown in figure 1. The viscous component of the drag is also called skin friction drag because it occurs on the object surfaces. Skin material, roughness, and skin microstructure are quite effects of the viscous drag beside the fluid viscosity. The pressure sourced component of the drag is called form drag or pressure drag.

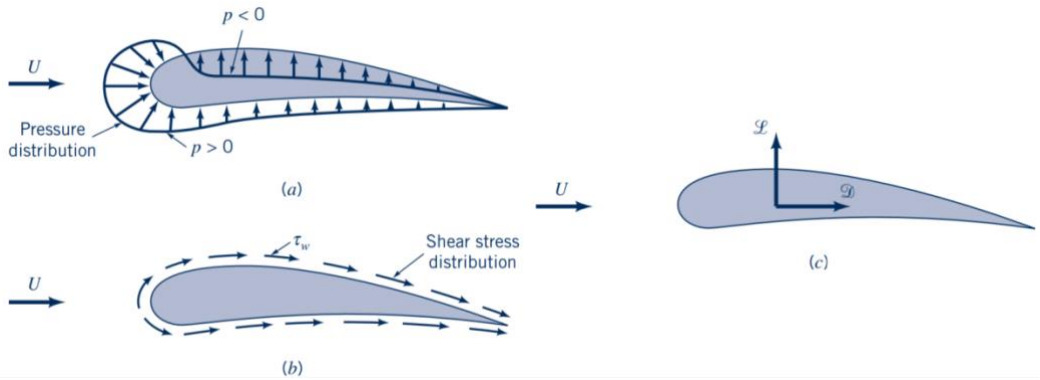


Figure 1: Forces from surrounding fluid (a) pressure force, (b) viscous force and (c) resultant force [1]

Equation (1) and (2) is used to determine the total drag and coefficient of drag. Also, it can be useful to know local shearing stresses and pressure distribution around moving objects. The resultant forces (Drag) can be obtained from the experimental drag coefficient (Cd).

D = Total Drag = Pressure component of drag + Friction component of drag = Dp+Df

$$D = \int dFx = \int PCos\theta dA + \int \tau x Sin\theta dA \quad (1)$$

$$Dp = \int PCos\theta dA$$

$$Df = \int \tau x Sin\theta dA$$

Where θ is the angle between surface normal and free stream flow direction (x-direction)

$$Cd = \frac{D}{\frac{1\rho U^2 A}{2}} \quad (2)$$

While viscous drag accounts for a larger share of the drag at low Re, pressure drag accounts for a larger portion of the drag at high Re, where inertial forces dominate. Drag is proportional to the square of velocity as shown by the simple formula above. Watercraft required power to overcome drag and it will be proportional to the cube of the velocity. As a result, finding strategies to minimise drag coefficient without compromising velocity is critical. The water lubrication technique uses boundary layer separation to reduce drag. When the boundary layer separates streamlines no longer flow parallel to the object surface and each other. Local shearing stress is zero at the separation zone. There are two basic types of boundary layer separation they are pressure-based and geometry-based separations.

In geometry-based boundary layer separation, when the shape of a moving object changes abruptly or sharp turns on the flow can lead to occur immediate separation at the corner (B) which is shown in figure 2 (b). Fluid cannot follow the object's surface due to inertial forces. If you desire a streamlined object, you should avoid this type of contour. However, sometimes it can be an inevitable boundary layer or be employed for design purposes. For example, cavitation techniques for reducing drag.

Flow around the object transfers kinetic energy into potential energy (as pressure) in pressure-based boundary layer separation, depending on the shape of the object (or vice versa). The exchange occurs without loss in the inviscid flow and does not result in separation. Although there is a boundary layer in an actual flow that causes severe viscosity effects and energy loss. As a result, the conversion of kinetic energy to potential energy is never 100 %. The separation occurs when the flow does not have enough energy to enter the high-pressure area due to actual flow losses. In basic analyses, we can assume the upper boundary of the boundary layer as a streamline to discover pressure distribution as outside the boundary layer inviscid flow equations is valid and inside the

boundary layer, perpendicular pressure gradient is negligible. The pressure distribution on the boundary of the boundary layer becomes pressure distribution inside the boundary layer shelves. The pressure distribution along the object surface is a highly important factor in boundary layer separation. The pressure-based boundary layer separation occurs due to a negative pressure gradient on the surface. Surface pressure rises owing to streamlining expansion in this form of boundary layer separation alongside the object. Pressure-based boundary layers form on gradually longer surfaces as seen in figure 2 (a). When pressure rises, the fluid decelerates and loses energy due to momentum loss in viscous flow. Separation might occur when the flow ultimately comes to a halt.

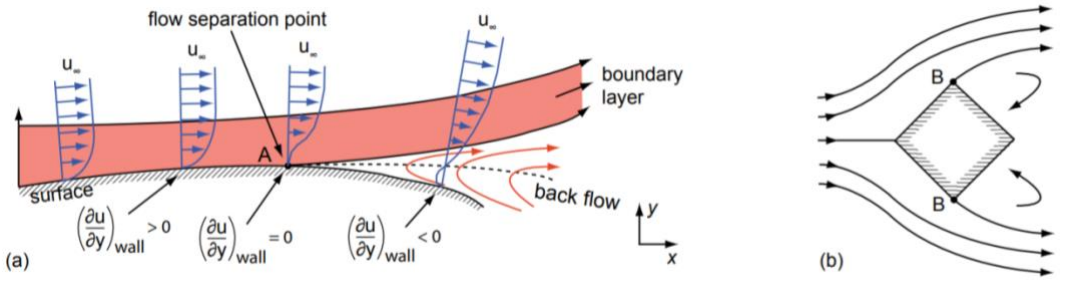


Figure 2: (a) Pressure-based and (b) geometrically-based flow separation [2-4].

The fluid accelerates initially due to a positive pressure gradient (figure 2 (a)). This type of flow is advantageous to the boundary layer since it does not cause separations and tends to maintain laminar flow conditions. The flow speed is constant and fluid acceleration is zero when the pressure gradient is zero. The flow starts to slow down along the streamlines beyond that point $(\frac{\partial P}{\partial x})_{wall}>0$, which could be due to momentum loss or geometry. Separation phenomena require an unfavourable pressure gradient, however, this is insufficient. At the same time, viscous shear stresses demand a long-term retarded fluid so this type of separation does not occur suddenly. The wall first declines and then becomes zero due to the adverse pressure effect in the boundary layer $(\frac{\partial u}{\partial y})$ and u=0 due to the no-slip condition on the wall it appears at a point of stagnation and the flow has begun to divide. Backflow is a fascinating phenomenon that occurs when one flow opposes another. Figure 3 shows the boundary layer velocity distribution before and after the separation of the boundary layer.

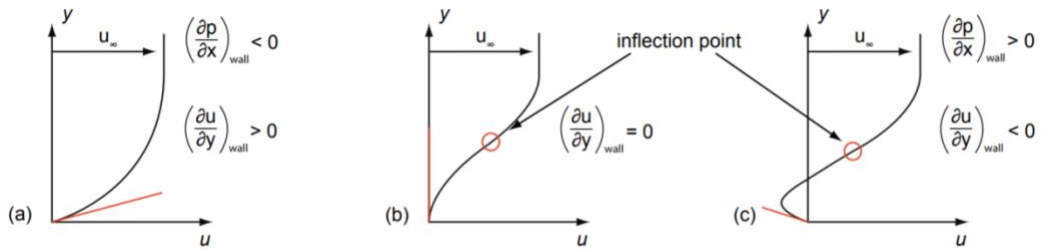


Figure 3: Flow profile of an airfoil (a) before boundary layer separation (b) during boundary layer separation and (c) after boundary layer separation [2].

Figure 3 (a) shows that the separation favours a boundary layer pressure gradient along the flow direction $(\frac{\partial P}{\partial x})_{wall}<0$ indicates that the flow is accelerating and $(\frac{\partial u}{\partial y})_{wall}>0$ indicates that momentum is being transferred along the flow direction and boundary layer. The velocity profile inside the boundary layer is steeper due to the pressure acceleration effect (Shown with a red line). This inclination will steadily decrease until it reaches point b, where it will become zero and then negative after separation (c). Figure 3(b) indicates that there is no shear force on the wall and that the fluid does not move in the x-direction when $(\frac{\partial u}{\partial y})_{wall}=0$. The pressure forces work to decelerate the fluid along the surface when $(\frac{\partial P}{\partial x})_{wall}>0$ which is represented in figure 3(c). Because of the strong vorticity and unpredictable eddies, the boundary layer dissipates after the separation point or line, and the wake zone begins. The turbulent boundary layer and the wake zone are two distinct phenomena. The laminar boundary

layer area may be the starting point for wake and separation. The different types of boundary layer separation are shown in figure 4.

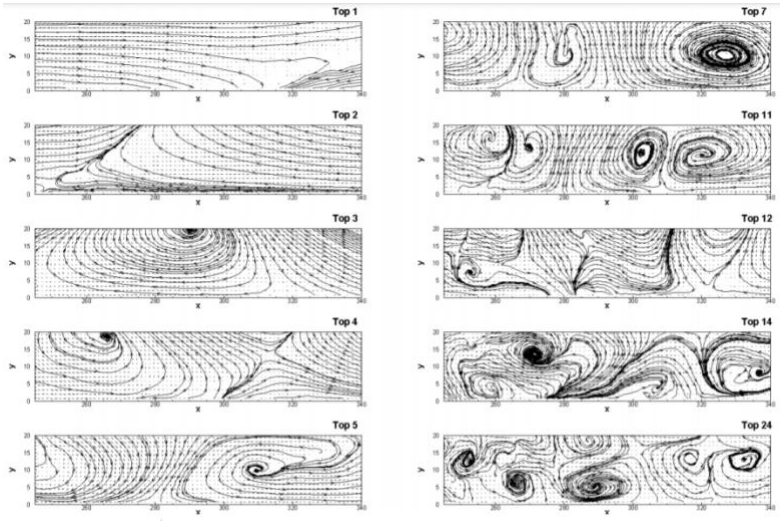


Figure 4: Boundary layer flow separation types [5].

Separated flow can be reattached in its natural nature of flow under certain conditions. When there is a separation in the laminar boundary layer section due to insufficient adverse pressure, the flow may shift to the turbulent boundary layer, where it can reattach due to the higher energy of the turbulent boundary layer flow. The size of the laminar recirculating zone is influenced by initial flow disturbances and the form features of the object. In the studies, the reattached flow had a detrimental impact on flow drag characteristics. Furthermore, there is an unfavorable flow in the recirculating zone, which necessitates a lower or negative frictional drag. The formation of reattachment of separated flow is shown in figure 5.

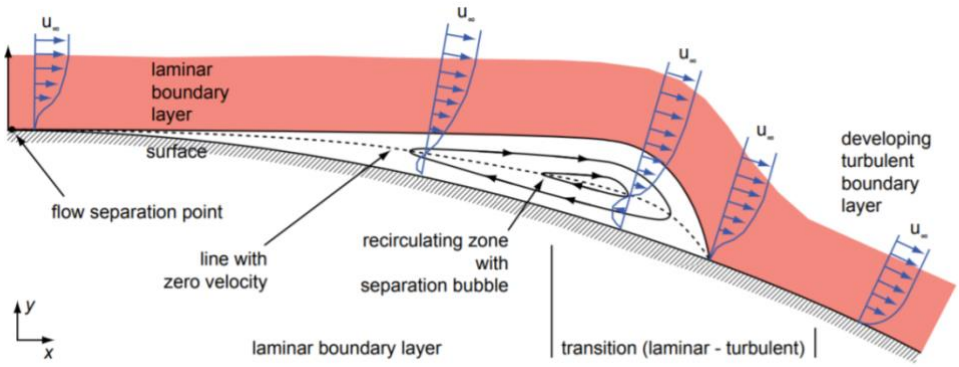


Figure 5: Reattachment of separated flow [6].

2. Water Lubrication Technique

The water lubrication technique uses flow separation for drag reduction. Water jets are used to change boundary layers in the water results drag reduction and also the creation of negative drag. Figure 6 depicts the drag (D) and shear stress (τ) gradients created by airflow around a flat plate. As shown in figure 7, the produced friction drag works against the thrusting flow. Shearing stress must be necessary to achieve negative drag as seen in figure 8, after separation the shear forces against the flow direction can be detected.

Figure 6: Expected friction drag and shear stress and their directions on a flat plate

Figure 7:Direction of the drag and shear stress on a flat plate following water lubrication.

Water lubrication uses water jets to produce artificial separation points along the surface. Backflow (reverse flow) occurs near a separation point, causing reverse shear stresses, which aid in understanding the water jet lubrication process. On the other hand flat plate separation does not increase the wake region. Water jets from 1 mm holes are predicted to cause separation and reverse flow. This makes sense because surface jets carry adjacent fluids as well as resulting in recirculating zones and reverse shear stress. Water lubrication technique is environmentally friendly and a cheaper solution to reduce frictional drag, transportation cost and emissions.

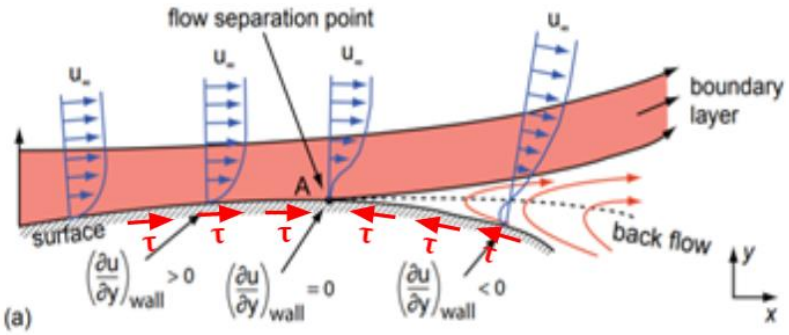


Figure 8: Reverse shear stress and the reverse flow around a separation point

3. Literature Review

Drag reduction and boundary layer modification were performed using various drag reduction techniques to decrease the drag force [7-9], such as dielectric barrier discharge plasma actuators for energizing boundary flow and drag reduction [10-11] , also different types of actuators were used to accelerate boundary layer [12]. Another technique to reduce drag is by creating cavitations using water or air [13]. Air lubrication develops and uses a layer near the object's surface that has a far lower average viscosity and density than water. There have been numerous theoretical and experimental investigations have been conducted on the boundary layer created by a fluid jet in order to reduce drag [14].By installing an air lubricating system beneath the ship's hull, air cavities can be exploited to reduce frictional drag. The ship's speed might be enhanced while using air as a lubricant, reducing both fuel consumption and environmental impact. Computational fluid dynamics are used to analyze fluid flow [15]. To conduct numerical analysis fluent software is used, which provides the ability to create and simulate boundary layer with cost-effective and high accuracy. Sometimes numerical analysis may give more accurate results than the real experiment. It gives comprehensive information about simulation prediction for different flow conditions [16-18].Sometimes in the given conditions (flow velocity) turbulent flow delays separation and gives less drag than laminar flow[19-20].These techniques appear to be unattractive to the boundary layer at first glance. When adopting this procedure, rough surfaces produce less drag than smooth surfaces. Another attractive method for reducing frictional drag is air lubrication, which is frequently used in commercial applications and offers favourable and encouraging results [21-24]. The goal of most of drag reduction strategies is to prevent flow separation and reverse flow. However, the water lubrication approach used a water jet to induce flow separation and reverse flow [25-29], [34].

4. Numerical Analysis

Before implementing in a real-time application, finite element analysis is used to forecast the reaction of a working component when it is exposed to external loads, fluid flow, heat transfer, and other physical phenomena. The distribution of stress, strain, total deformation, flow velocity, shear stress, and other parameters can be determined by using finite element analysis to analyze the component. We can predict the output values based on these results without having to implement in a real-time application [30-32]. Fluent software is utilized to forecast the percentage of drag reduction when water lubrication is applied. A two-dimensional model of a flat-plate (1000 mm) structure was constructed and evaluated with 9 holes (1mm size) drilled into the flat plate to inject water in the form of a jet between the distance of 100 mm. Figures 9&10 demonstrate the imaginary drag reduction tile and boundary conditions employed in the CFD study. The water jet is injected through the holes in the watercraft's wall into the external surface. The watercraft is surrounded by a high-velocity water flow with a velocity of 8 m/s^2.

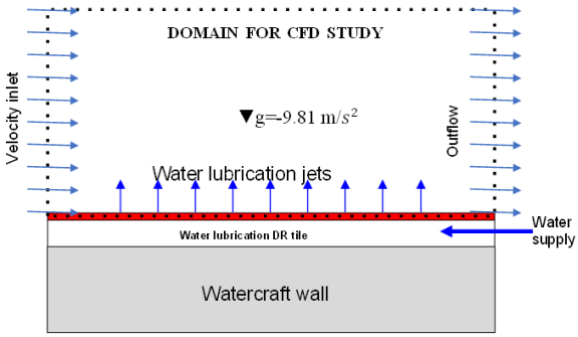


Figure 9:Imaginary drag reduction tile used for water lubrication.

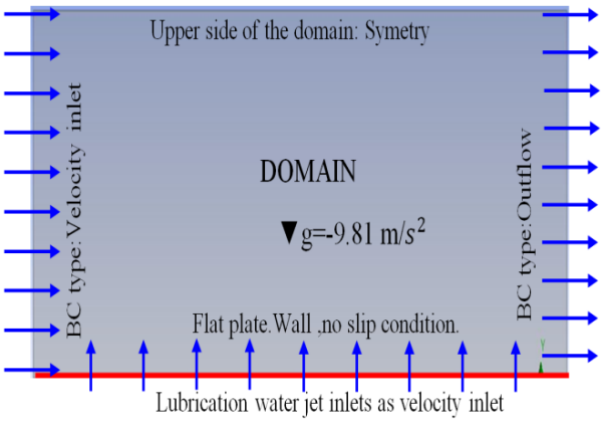


Figure 10:Domain used for CFD study with boundary conditions.

5. Mesh independency

mesh size (k)	drag (N)
19	3,42
35	-0,6
65	-3,5
88	-3,9
114	-4,4
161	-5,33
207	-3,35
394	-3,58
447	-3,57

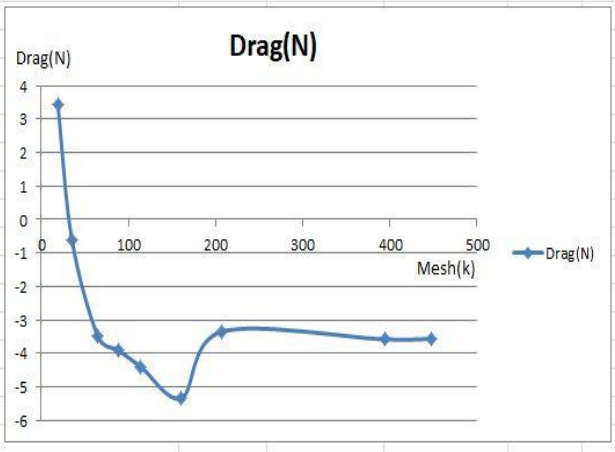


Figure 11: Drag results for different node sizes (12 kg/s airflows).

The analysis was run with various node counts to determine the optimum node count, and the results were analyzed to establish the optimum node count. Figure 11 shows a graph of mesh size and drag achieved with node sizes ranging from 19 k to 447 k. The drag value decreases gradually from 207 k to 447 k nodes and maintains a steady-state condition between 394 k and 447 k nodes. The drag difference between these nodes is roughly 0.3 %. As a result, the analysis was carried out with a node of 447 k which is shown in figure 12.

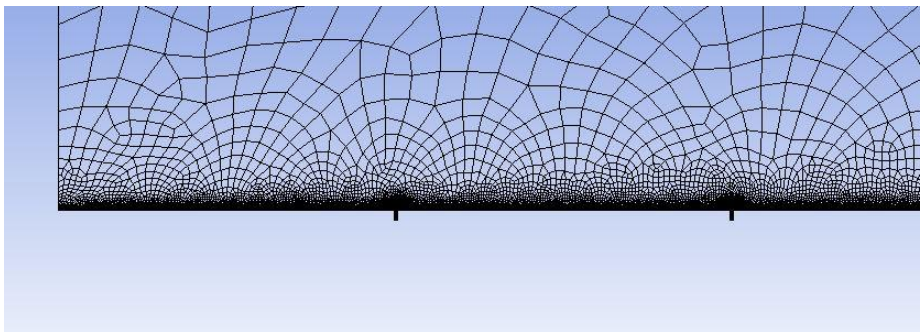


Figure 12: Meshing of the domain for 447k node

The friction drag was calculated using equation (3) as 108.4 N by considering water jet flow (zero), area of the flat plate (1 m^2), water flow velocity (8 m/s), water density (998.2 kg/m^3) and viscosity (0.001003 kg/m-s).

$$C_f = \frac{\tau_w}{\frac{\rho U^2}{2}} \quad (3)$$

From these values, it can be calculated that Re is 7.96 $x10^6$ which means that flow is the turbulent and the theoretical value of C_f obtained using equation (3) is 3.39 x 10^{-3}. Figure 13 shows the predetermined value of C_f it is roughly around 3.2 x 10^{-3} for smooth plates, also the difference between the outcomes of numerical analysis and theoretical analysis is 6 %.

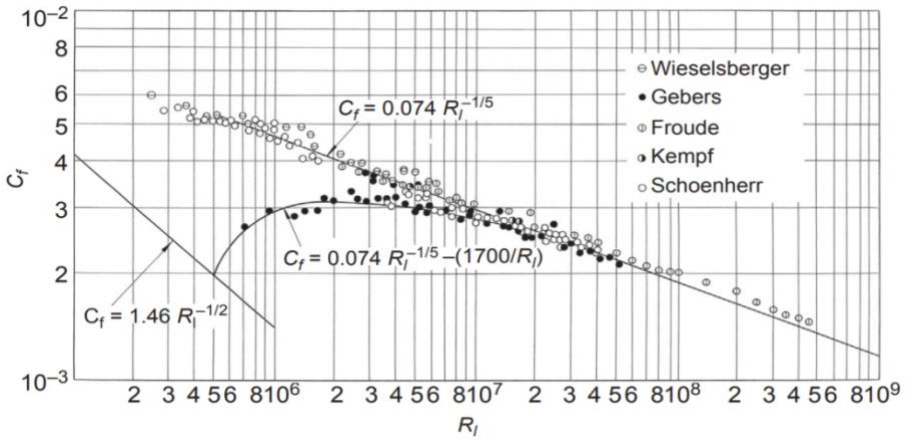


Figure 13:Experimental and theoretical coefficient of friction drag for flat plate [33].

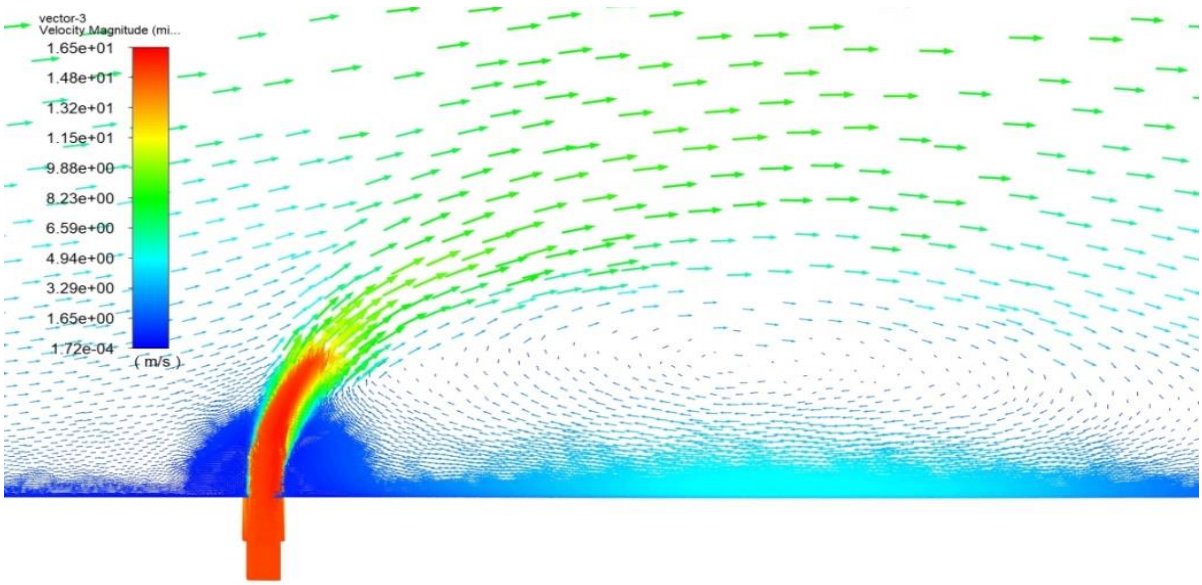


Figure 14: Reverse flows around the water lubrication port.

Figure 14 depicts the formation of a reverse flow (negative drag) and recirculating zone on the rear side of the water jet that is introduced from the watercraft (flat plate). Only one port is zoomed in and exhibited for better understanding. Here, the force exerted by the jet causes the velocity of the flow surrounding it to decrease. Low frictional force can be accomplished by lowering the frictional drag value by reducing the flow velocity between the wall and the water surface. For 1 mm wide slots, a flow output velocity of 12 m/s is necessary to achieve negative drag. Even though reverse flow and drag reduction can be achieved with an output velocity of 3 m/s and strong reverse flows can be created with an output velocity of 4 m/s.

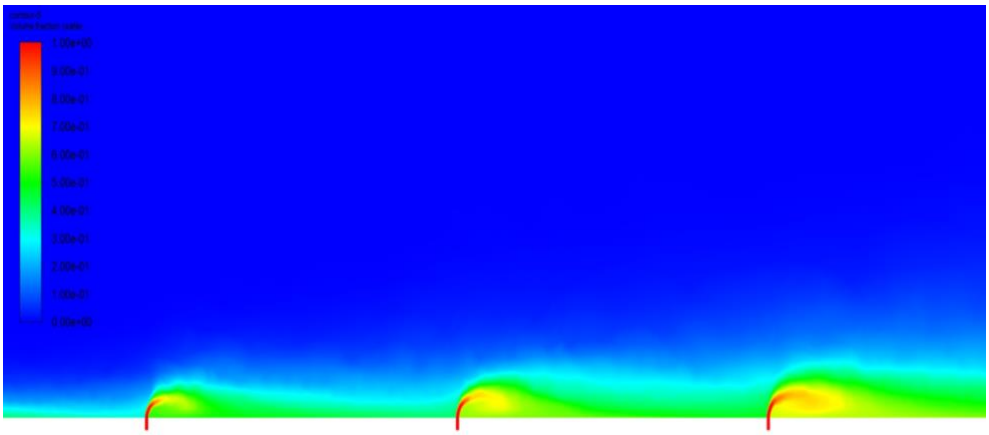


Figure 15: Water jet distributions and their fractions on the domain.

Figure 15 depicts a section of the flow field with three output ports, as well as the effectiveness of water jets. The size and variations of the recirculation zone are depicted in green regions with relation to the jet velocity on the plate, which is gradually raised from the initial water jet location to the last one.

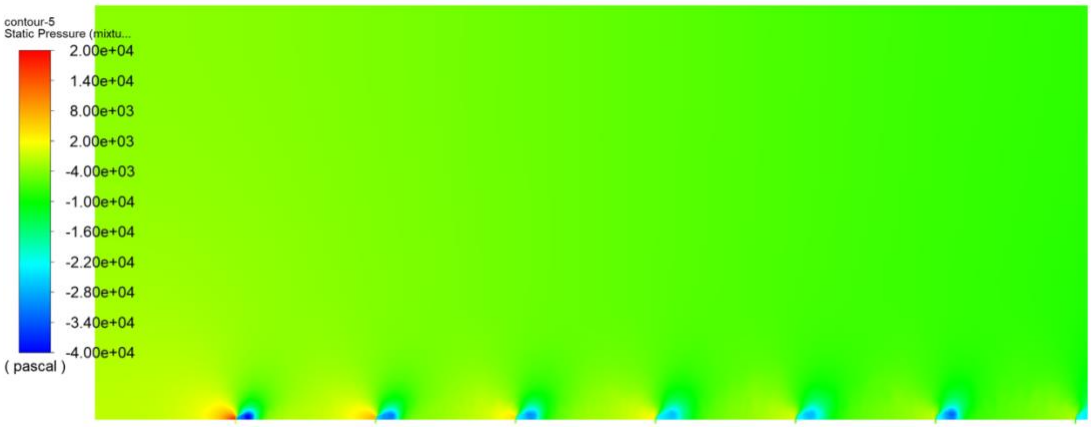


Figure 16:Contours of static pressure.

Figure 16 depicts the pressure distribution before and after the jet, as well as the pressure difference caused. The backward flow is caused by the generated water barrier. Used water can be pulled from the front of the boat, where the high pressure will aid in reducing pressure drag. In addition, when utilised in conjunction with drag reduction strategies, water jets can produce a hollow by acting as a fluid curtain. From the beginning of the water jet port to the end, the developed pressure can be gradually reduced. It is depicted as a blue zone in figure 16.

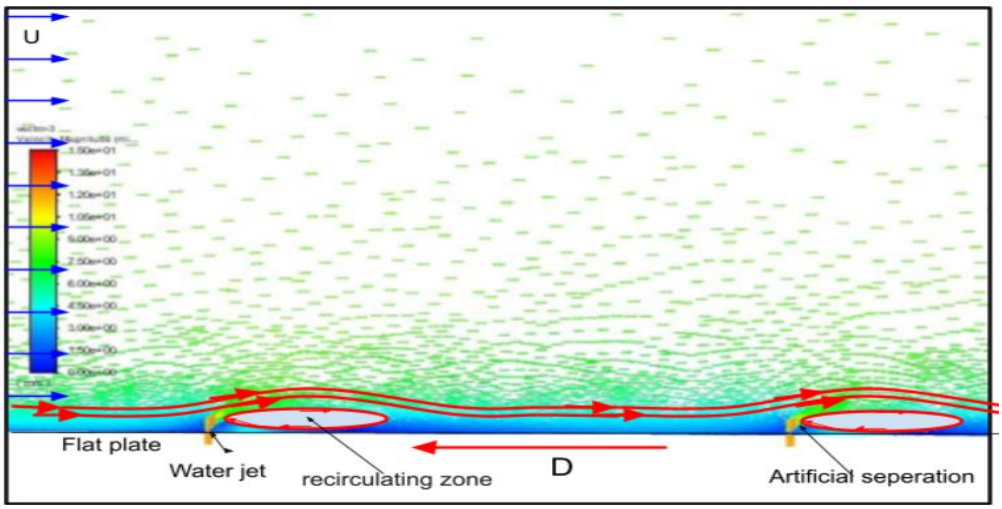


Figure 17: Reverse flow around artificial separation point.

A general view of the flow field during water lubrication is shown in figure 17. Here two water jets are only showcased for discussion purposes (on the plate there are 9). Constantly maintained distances between jets are 100 mm. After injecting water jets into the bottom of the plate the flow is reversed on the plate once the recirculation zones begin which means shear stress is produced against the flow, also the frictional forces thrust the plate against the flow. The flow between the recirculation zones is not reversed, although it is significantly slower. This slow environment on the plate resulted in a slow and thick boundary layer. The velocity of the flow is slowed or reversed as a result of water lubrication in the unique boundary layer, which reduces frictional drag and increases thrust forces.

Water jet velocity m/s	Calculated drag (N)	DR %	Water jet flux kg/s
15,00	-32,88	133,7	134,8
12	-3,99	104,1	107,8
9	21,05	78,4	80,8
6	45,78	53,1	53,9
3	80,13	17,9	27,0
0	136,5	-39,9	0,0

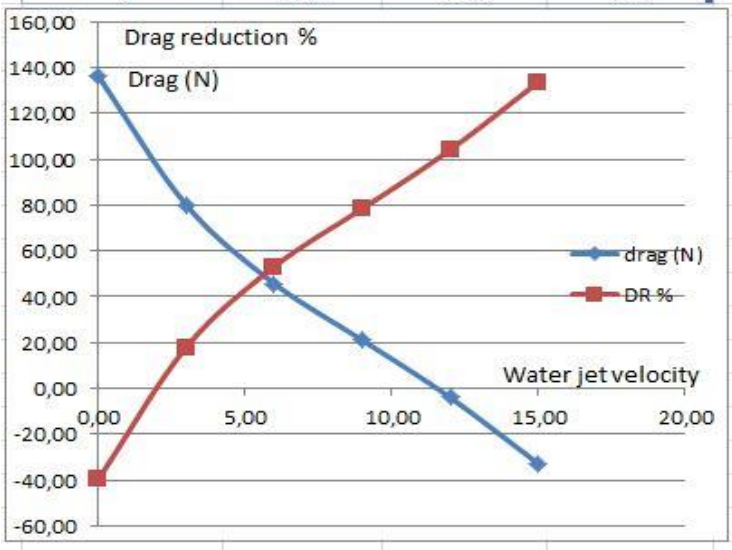


Figure 18: Drag reductions and drags for water jet velocity.

The results of a CFD simulation for a variable water jet velocity are shown in figure 18. In this analysis, the free stream velocity is set at 8 m/s. It is clear from the table and graph is the water jet velocity was increased to 12

m/s, and the percentage of drag reduction climbed to 104% with reducing drag. When the water jet's velocity is increased beyond 12 m/s negative drag is produced which indicates the creation of thrust forces.

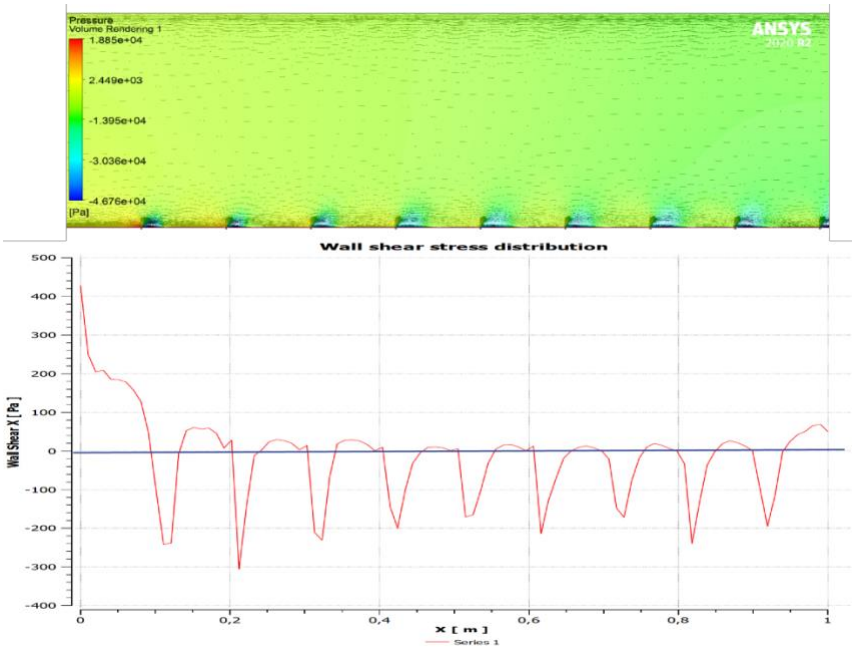


Figure 19: Distribution of wall shear stress

During the flow, shear stress is created owing to friction formed on the wall surface which results in the production of drag force, which varies depending on the shear stress produced on the wall surface. Figure 19 depicts the obtained shear stress distribution of the wall, which clearly illustrates that negative drag force is created in the low shear stress zones. Negative shear stress leads to reduces frictional drag and increases thrust force, which helps to increase the speed of watercraft and also reduces the fuel consumption required to sail the watercraft.

6. Conclusion

Separation of flow is an undesirable occurrence as a turbulent flow which is commonly employed to reduce drag by creating turbulence (Turbulent generators). This study has used separation to reduce frictional drag. Using computational fluid dynamics software (CFD), numerical analysis is used to simulate the reduction of drag caused by separating the flow by water jets. In this simulation research, an adverse flow impact was established across the entire surface, resulting in a reverse flow. Continuous changes in drag and shear stress direction can be obtained over the surface during the simulation, which helps reduce frictional drag resistance. As a result of the findings, it was discovered that the slow or adverse flow over the plate generated a separate layer which helps to decrease frictional drag reduction because of its velocity profile. Water is fed in the shape of a jet to the bottom of the watercraft to produce a flow separation and aid in the creation of reverse flow to reduce frictional drag. The CFD results demonstrate a 134 % reduction in friction drag, as well as the possibility of achieving thrust rather than resistance. Furthermore, for a water velocity of 3 m/s, a 17 % reduction in drag can be accomplished. In this study, simulation works only carried out and for better and more accurate results miniature model of the watercraft will be designed and built for testing, optimization and feasibility studies.

References

Munson, B. R., Okiishi, T. H., Rothmayer, A. P. (2013). *Fluid Mechanics: Fundamentals of Fluid Mechanics (7th Edition)*. John Wiley and Sons Inc: New York.

Sturm, H., Dumstorff, G., Busche, P., Westermann, D., Walter, L., W. (2012). Boundary layer Separation and Reattachment Detection on Airfoils by Thermal Flow Sensors. *Sensors*. 12(11), 14292-306. https://doi.org/10.3390/s121114292.

Schlichting, H., Gersten, K., Krause, E. (2008). *Grenzschicht-Theorie*, 10th ed. Springer Berlin. 377–408. https://doi.org/10.1007/3-540-32985-4.

Bohl, W., Elmendorf, W. (2008). *Technische Stromungslehre*. 14th ed. Vogel-Fachbuch: Wurzburg, Germany, 260–302.

Uruba, V., Knob, M. (2009). Dynamics of a Boundary layer Separation. *Engineering Mechanics*. 16(1), 29–38.

Gad-el Hak, M. (2000). Flow Control-Passive, Active, and Reactive Flow Management, *1st ed.; Cambridge University Press*. Cambridge, UK. 150–203.

David, C. H. (1968). Boundary layer Control. Film Notes. *National Committee for Fluid Mechanics Films*. Princeton University: Princeton.

Craven A. H. (1960). Boundary layers with Suction and Injection A review of published work on skin friction. *Royal Air Force Technical College*, Henlow. http://dspace.lib.cranfield.ac.uk/handle/1826/9420.

Seif, M. S., Tavakoli, M. T. (2004). New Technologies for Reducing Fuel Consumption in Marine Vehicles, *XVI Symposium* SORTA.

Wang, J. J., Choi, K.S., Feng, L. H. (2013). Recent Developments in DBD Plasma Flow Control, *Progress in Aerospace Sciences*. **62**, 52-78. https://doi.org/10.1016/j.paerosci.2013.05.003.

Shimizu, K., Boundary layerajan, M. (2018). Dielectric Barrier Discharge Microplasma Actuator for Flow Control, *Actuators. DOI: 10.5772/intechopen.75802*.

Gerbedon, J.C.,Talbi, A.,Viard, R., Preobrazhenskya, V., Merlenb, A., & Pernod, P. (2015). Elaboration of compact synthetic micro-jets based on micro magneto-mechanical systems for aerodynamic flow control. *Procedia Engineering*. 120, 740 -743. https://doi.org/10.1016/j.proeng.2015.08.789.

Yanga, D., Xiong, Y. L., Guod, X. F. (2017). Drag Reduction of a Rapid Vehicle in Supercavitating Flow. *International Journal of Naval Architecture and Ocean Engineering*. 9(1), 35-44. https://doi.org/10.1016/j.ijnaoe.2016.07.003.

Schlichting, H. (1968). *Boundary-layer Theory*. 6th edition, McGraw-Hill, New York.

Vijayan, S.N., Sendhilkumar., S., Kiran Babu, K. M., Duraimurugan, G.K., & Deepak, P. (2018). CFD Analysis of Frictional Drag Reduction on the Underneath of the Ship's Hull Using Air Lubrication System, *International Journal of Mechanical Engineering and Technology (IJMET)*. 9(4), 408–416. https://iaeme.com/Home/article_id/IJMET_09_04_046.

David Paul, D., Vijayan, S.N., Navish Kumar. (2019). Investigation on thermal effects of Al_2O_3 Nanoparticles mixed with water in forced convection micro channel using Computational fluid dynamics. *International Journal of Engineering and Advanced Technology*. 8(3),217-222. https://www.ijeat.org/wp-content/uploads/papers/v8i3/C5792028319.pdf.

Kawakita, C., Sato, S., & Okimoto, T. (2015). Application of simulation technology to Mitsubishi air lubrication system. *Mitsubishi Heavy Industries Technical Review*. 52(1), 50-56.

Silillberschmidt, N., Tasker, D., Pappas, T., & Johannesson, J. (2016). Silverstream system - air lubrication performance verification and design development. *Conference of Shipping in Changing Climate*, Newcastle, UK, 10-11.

Merryisha, S., Parvathy, R. (2019). Experimental and CFD Analysis of Surface Modifiers on Aircraft Wing: A Review. *CFD Letters*. 11(10), 46-56. https://akademiabaru.com/submit/index.php/cfdl/article/view/3516.

Spálenský, V., Rozehnal, D. (2017). CFD Simulation of Dimpled Sphere and its Wind Tunnel Verification, *MATEC Web of Conferences*. 107 (1–3), 00077.

McCormick, M. E., Bhattacharyya, R. (1973). Drag reduction of a submersible hull by electrolysis. *Naval Engineering* 85, 11-16. https://doi.org/10.1111/j.1559-3584.1973.tb04788.x.

Yuichi Murai. (2014). Frictional Drag Reduction by Bubble Injection. *Experiments in Fluids*. 55 (1773). https://doi.org/10.1007/s00348-014-1773-x.

Takahashi, T., Kakugawa, A., Nagaya, S., Yanagihara, T., & Kodama, Y. (2001). Mechanisms and scale effects of skin friction reduction by microbubbles. *Proc. 2nd Symp. on the Smart Control of Turbulence*, University of Tokyo, 1–9.

Watanabe, O., Masuko, A., Shirose, Y. (1998). Measurements of Drag Reduction by Microbubbles using very long Ship Models. *Journal of the Society of Naval Architects of Japan*. 183, 53–63. https://doi.org/10.2534/jjasnaoe1968.1998.53.

Ahmed Z. Al-Garni., Abdullah M. Al-Garni., Saad A. Ahmed., & Ahmet Z. Sahin. (2000). Flow Control for an Airfoil with Leading-Edge Rotation. *Journal of Aircraft*. 37(4), 617-622.

Shao, N., Yao, G., Zhang, C., Wang, M. (2017). A New Method to Optimize the Wake Flow of a Vehicle: The Leading Edge Rotating Cylinder. Mathematical Problems in Engineering. 1, 1-16. https://doi.org/10.1155/2017/5781038.

Diamond, P., Harvey, J., Katz, J., Nelson, D., & Steinhardt, P. (1992). Drag Reduction by Polymer Additives. *The MITRE Corporation*, McLean, Virginia.

Wang, J.J., Choi, K.S., Feng, L.H., Jukes, T.N., & Whalley, R.D. (2013). Recent Developments in DBD Plasma Flow Control. *Progress in Aerospace Sciences*. 62, 52-78. 10.1016/j.paerosci.2013.05.003.

Kazuo Shimizu., Marius Blajan. (2018). Dielectric Barrier Discharge Microplasma Actuator for Flow Control. *Actuators*. 10.5772/intechopen.75802.

Vijayan, S. N., Sendhilkumar, S., & Kiran Babu, K. M. (2015). Design and analysis of automotive chassis considering cross-section and material. *International Journal of Current Research*. 7(05), 15697-15701. https://www.journalcra.com/article/design-and-analysis-automotive-chassis-considering-cross-section-and-material.

Singarajan Nagammal Vijayan., Sathiavelu Sendhilkumar. (2015). Structural Analysis of Automotive Chassis Considering Cross-Section and Material. *International Journal of Mechanical Engineering and Automation.* 2(8), 370-376.

Vijayan, S.N., Makeshkumar, M. (2012). Material Specific Product Design Analysis for Conditional Failures – A Case Study. *International Journal of Engineering Science and Technology*. 4(03), 976-984.

Nakayama, Y. (2018). *Introduction to Fluid Mechanics*. 2nd Edition, Butterworth-Heinemann.

Atilla Uygar Sönmez (2022). Water Lubrication for Friction Drag Reduction. *International Scientific Research Congress Dedicated to the 30th Anniversary of Baku Eurasia University,* 1198-1206.

Nomenclatures

TF	Total acting force,
Cd	Coefficient of drag
BL	Boundary layer
DR	Drag reduction
D	Drag
Dp	Pressure drag
Df	Friction drag
Dw	Wave drag
Re	Reynolds number
Fr	Froude number
PBS	Pressure based separation
GBS	Geometry based separation

ASIAN INSTITUTE OF RESEARCH
Connecting Scholars Worldwide

The Asian Institute of Research
Engineering and Technology Quarterly Reviews
Vol.5, No.2, 2022: 30-37
ISSN 2622-9374

Construction Procurement: A View from Europe

Slavica Joković[1]

[1]Independent Consultant and Visiting Lecturer. Email: slavica.jokovic.author@gmail.com

Abstract
This paper examines the main characteristics of construction procurement and analyses the country`s case of Serbia. With particular reference to the new Law on Public Procurement in Serbia and the European Union Directive on Public Procurement (Directive 2014/24/EU), this article describes some features of construction procurement regarding bidding documents, requirements for participation in public procurement and public procurement procedures. Furthermore, for the purpose of this analysis, the common definitions of work and public works contracts are included, as well as some specific situations. In addition, it gives an overview of the relevant legislative provisions to be taken into account when procuring construction works. Afterward, the paper points out the complexity and importance of construction procurement as well as the need to reduce irregularities in procurement procedures. Finally, concluding remarks are included.

Keywords: Construction, Public Works Contract, Work, Public Procurement, Directive on Public Procurement

1. Introduction

The aim of this article is to give a review of construction procurement from the point of view of the European Union Directive on Public Procurement (Directive 2014/24/EU)[1] and national legislation on public procurement in Serbia, as a country case. The paper includes an examination based on the legislative framework in the European Union and Serbia, concerning construction procurement, with special emphasis on the provisions on technical specifications, requirements for participation in public procurement and public procurement procedures. It should be stressed that the harmonization of national legislation with the EU Directive in the field of public procurement is a strategic goal of public procurement development in Serbia.[2]

In Serbia, the area of public procurement is regulated by the new Law on Public Procurement ("Official Gazette of the Republic of Serbia," no. 91/2019).

This Law regulates: the rules of the public procurement of supplies, services and works, as well as the procedure of protection of the rights in public procurement procedures, and other issues relevant to public procurement. Namely, the new Law on Public Procurement governs: scope of application, public procurement procedures and techniques, centralization, preparation for conducting public procurement procedures (including public

[1] DIRECTIVE 2014/24/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on public procurement and repealing Directive 2004/18/EC
[2] See: The Public Procurement Development Strategy in the Republic of Serbia for the period 2014-2018.

procurement plan), technical specifications, requirements for participation in public procurement and contract award criteria, the utility activities, the Public Procurement Portal, manner of recording data and delivering reports.

In addition, the Law contains nine annexes, including Annex 1: List of activities in construction (such as construction of buildings, civil engineering, construction of highways, roads, construction of water projects, and other construction works).

Furthermore, according to the new Law on Public Procurement, it is envisaged that certain provisions should be applied from the day of the accession of the Republic of Serbia to the European Union.

In general, there is a need for further harmonization with the Directives in the area of public procurement (namely, Directive 2014/24/EU and Directive 2014/25/EU[3]), and significant progress should be made from the point of view of public procurement regulatory and institutional framework, as well as practice.

2. Explanation of Terminology

In the context of this research, relevant definitions are applied according to the EU Directive on Public Procurement, which is as follows:

- Public contracts are "contracts for pecuniary interest concluded in writing between one or more economic operators and one or more contracting authorities and having as their object the execution of works, the supply of products or the provision of services;"[4]
- public supply contracts are "public contracts having as their object the purchase, lease, rental or hire-purchase, with or without an option to buy, of products;"[5]
- public service contracts are "public contracts having as their object the provision of services other than those referred to in point 6;"[6] (*point 6 of Article 2 concerns public works contracts*)
- public works contracts are "public contracts having as their object one of the following:
  (a) the execution, or both the design and execution, of works related to one of the activities within the meaning of Annex II;
  (b) the execution, or both the design and execution, of a work;
  (c) the realization, by whatever means, of a work corresponding to the requirements specified by the contracting authority, exercising a decisive influence on the type or design of the work;"[7]
- a work means "the outcome of building or civil engineering works taken as a whole which is sufficient in itself to fulfill an economic or technical function;"[8]
- economic operator means "any natural or legal person or public entity or group of such persons and/or entities, including any temporary association of undertakings which offers the execution of works and/or a work, the supply of products or the provision of services on the market;"[9]
- bidder (tenderer) means an economic operator that has submitted a bid (tender);
- candidate means "an economic operator that has sought an invitation or has been invited to take part in a restricted procedure, in a competitive procedure with negotiation, in a negotiated procedure without prior publication, in a competitive dialogue or in an innovation partnership";[10]
- procurement document means "any document produced or referred to by the contracting authority to describe or determine elements of the procurement or the procedure, including the contract notice, the prior information notice where it is used as a means of calling for competition, the technical specifications, the descriptive document, proposed conditions of contract, formats for the presentation of documents by candidates and tenderers, information on generally applicable obligations and any additional documents".[11]

[3] DIRECTIVE 2014/25/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC
[4] Directive 2014/24/EU Art.2 (5)
[5] Directive 2014/24/EU Art.2 (8)
[6] Directive 2014/24/EU Art.2 (9)
[7] Directive 2014/24/EU Art.2 (6)
[8] Directive 2014/24/EU Art.2 (7)
[9] Directive 2014/24/EU Art.2 (10)
[10] Directive 2014/24/EU Art.2 (12)
[11] Directive 2014/24/EU Art.2 (13)

In addition, some more useful terminology explanations about public procurement are included,[12] such as the following:

- Utility activities are economic activities in the areas of water, energy, transport and postal services.
- Public procurement by lots is procurement whose subject is subdivided into several separate units of the same kind, and which is designated as such in the call for competition and bidding documents.
- Common Procurement Vocabulary is the reference classification system for subjects of public procurement, applicable to public procurement contracts, which simultaneously ensures conformity with other existing classifications.
- The life cycle means all consecutive and/or interlinked stages, including necessary research and development, production, trading and conditions of trading, transport, use and maintenance, throughout the existence of the product or the works or the provision of the service, from raw material acquisition or generation of resources to disposal, clearance and end of service or utilization.
- Life cycle costing shall, to the extent relevant, cover parts or all of the following costs over the life cycle of a product, service or works:
    - costs borne by the contracting authority or other users, such as: costs of acquisition; costs of use, such as consumption of energy and other resources; maintenance costs; end of life cycle costs, such as collection and recycling costs;
    - costs imputed to external environmental factors linked to the product, service or works during its life cycle, provided their monetary value can be determined and verified, and which may include the cost of emissions of greenhouse gases and of other pollutant emissions, as well as other climate change mitigation costs.

3. Bidding Documents

Bidding documents specify the detailed rules to be applied in the bidding. It should be noted that the term "tender documents" used by FIDIC [13] and "bidding documents" used by the International Bank for Reconstruction and Development[14] have the same meaning.

The International Federation of Consulting Engineers (FIDIC)[15] was founded in 1913 in Belgium. FIDIC adopted the first General Conditions for the Execution of Construction Works in 1957, and it adopted the General Conditions for the Relationships between the Contracting Authority and Consulting Engineer in 1963.[16]

In Serbia, as a country`s case, the Rulebook on the Content of Tender Documentation in Public Procurement Procedures regulates in more detail the content of the tender documentation prepared by the contracting authority in the public procurement procedure.[17]

According to this Rulebook, the tender documentation in an open procedure depending on the nature of the subject- matter of procurement, contains: general information on the subject-matter of procurement (including a description of each lot, if the subject of the public procurement is formed by lots); type, technical characteristics (specifications), quality, quantity and description of goods, works or services, manner of control and provision of quality guarantee, deadline for execution, place of execution or delivery of goods, possible additional services; technical documentation and plans; criteria for qualitative selection of the business entity (grounds for exclusion and criteria for selection of the business entity), with instructions on how to prove the fulfilment of these criteria; data related to the contract award criteria (if the life-cycle cost is used, the data to be provided by tenderers and the method used by the contracting authority on the basis of that data to determine the life-cycle costs); data on the basis of which the bidders prepare the bid form; data on the basis of which the bidders prepare the form of

[12] See: Joković, S. (2022). "*Bidding to win-Detailed explanations*" in *WINNING PUBLIC PROCUREMENT CONTRACTS IN SERBIA MANUAL – SECOND UPDATED EDITION*
[13] FIDIC.(1987). *Conditions of Contract for Works of Civil Engineering Construction*
[14] World Bank.(1996). *Guidelines - Procurement under IBRD Loans and IDA Credits*
[15] acronym of Fédération Internationale des ingénieurs - Conseils, fr.
[16] Vukmir, B. (1980). *Works contracts - International / Ugovori o izvođenju investicijskih radova – međunarodni.* Centar za informacije i publicitet, p. 43.
[17] Rulebook on the Content of Tender Documentation in Public Procurement Procedures ("Official Gazette of RS", No 21/2021)

the statement on fulfilment of the criteria for qualitative selection of the business entity; forms of documents that are an integral part of the offer (including structure of the offered price); contract model; instructions to bidders on how to prepare a bid, etc.[18]

Concerning construction procurement, *s*pecifications usually define the materials and labor that are required for works execution. Because they do not include information regarding cost, quantity, or materialization (drawings), they have to be read in conjunction with the Bill of Quantities, Schedules, and Drawings. Since specifications provide basic requirements, they are produced in the first place. Therefore, they have the highest contractual priority among the above-mentioned documents.[19]

From the above definition of works (see: Section 2. Explanation of Terminology) derives their complexity and specific characteristics. The works include all activities related to the construction of a facility, so that the significant characteristics are especially concerning:

- great diversity of facilities and the works themselves, so that we can talk about each building as unique, even when two or more facilities are built on the same project, but on different locations - we can not talk about the same facility due to different, as field and climatic conditions, as well as conditions for the execution of works;
- individual production which in most cases is realized for a known customer (by order);
- the large volume and value of buildings that are long-lasting and have very different purposes, as well as the long-term performance of the work, all of which contribute to the extreme susceptibility to the effects of market trends;
- a large number of participants of different professions and occupations in the construction of the facility and its complexity, as well as the complexity of technological processes and coordination of work;
- significant differences in the organization and dynamics of work processes (and material and technical supply of construction sites) depending on the type of work (housing, industrial facilities, roads, bridges, tunnels, energy facilities, etc.);
- due to the exceptional complexity, scope, and long-term performance of obligations under the construction contract and the conditions in which the work is performed, various risks are associated with these activities (commercial, non-commercial);
- significant climatic, cultural and other differences in the area in which the works are performed, which lead to different working and living conditions on the construction sites.

Specifics and characteristics of the work indicate exceptional diversity and complexity in technical-technological, commercial, financial and organizational terms compared to other activities.[20]

4. Requirements for Participation in Public Procurement[21]

The criteria for selection of the economic operator in a public procurement procedure may relate to the following: fulfillment of conditions to perform the professional activity, as well as economic, financial, technical and professional capacities.

When determining the selection criteria, contracting authorities may only require a level of capacities that will ensure that an economic operator is capable of performing the public procurement contract.

According to the Law on Public Procurement in Serbia, as a rule, the bidder shall prove fulfillment of requirements for participation in public procurement procedures concerning economic, financial, technical and professional capacities by supplying corresponding evidence, such as:

[18] Ibid Art. 2
[19] https://construction-claim.com/sr/specifikacija-fidic/
[20] Joković, S. (2010). *International market of capital projects and economic development*. Institute for Business Research MBA. p. 19-20.
[21] See: Joković, S. (2022). "*Choice of participants*" in *WINNING PUBLIC PROCUREMENT CONTRACTS IN SERBIA MANUAL- SECOND UPDATED EDITION*

- appropriate bank statements; financial statements or extracts from financial statements; report of the bidder`s overall income and, if necessary, of the income of supplies, services or works covered by the public procurement contract, for the last three financial years;
- one or more of the following evidences:
    - a list of the works performed, accompanied by certificates of satisfactory execution and outcome for the most important works; a list of goods delivered or services provided, with the sums, dates and names of recipients; over at the most the past five years for works, or three years for goods and services;
    - an indication of the key technical staff or technical bodies involved, who will be responsible for quality control;
    - a description of the bidder`s technical equipment, quality assurance measures, and research and development capacity;
    - the educational and professional qualifications of the service provider or contractor or of its managerial staff, provided that such qualifications are not evaluated as a contract award criterion;
    - an indication of the supply chain management and tracking systems that the bidder will be able to apply when performing the contract;
    - a declaration of the bidder on accepting the quality control to be performed by contracting authority or authorized body in the country in which the bidder is established;
    - an indication of the environmental protection management measures that the bidder will be able to apply when performing the contract;
    - a statement of the average annual number of employees of the service provider or contractor, and the number of managerial staff for the last three years;
    - a statement of the tools, plant or technical equipment available to the service provider or contractor for the performance of the contract;
    - an indication of the proportion of the contract which the bidder intends to subcontract where the relevant criterion for qualitative selection is proved by relying on the subcontractor`s capacity;
    - with regard to the products which are the subject-matter of public procurement: samples, descriptions or photographs of products; certificates drawn up by the official quality control institutes or agencies of recognized competence, attesting the conformity of products clearly identified by references to technical specifications or standards.[22]

It should be noted that bidder which intends to subcontract a share of public procurement contract to subcontractor, in its bid shall indicate:

- which share of the contract it intends to subcontract (by subject-matter or in terms of quantity, value, or percentage),
- information about subcontractors,
- that the payment will be made directly to the subcontractor for the part of the contract it has executed, where the subcontractor requests that direct payments of due claims are made directly to it.[23]

Where the bidder has subcontracted a share of the public procurement contract to a subcontractor, the above information shall be included in the public procurement contract. In any case, the bidder is fully responsible to the contracting authorities for the execution of contractual obligations, regardless of the participation of subcontractors.

It is not necessary to have a local partner to win a public procurement contract in Serbia. Competition in public procurement procedures is open to any company or natural person from all countries. There are no additional requirements concerning the eligibility of foreign subjects as compared to those applying to national bidders.

[22] Public Procurement Law, Art. 123-124
[23] Public Procurement Law, Art. 131

Pursuant to the European Union Directive on public procurement, as a general rule, proof of the economic operator`s economic and financial standing, as well as technical ability may be provided by one or more of the means listed in Annex XII.[24]

Moreover, the contracting authority shall determine the criteria for the selection of an economic operator, bearing in mind the subject-matter of public procurement.

5. Public Procurement Procedures

When awarding public contracts, contracting authorities in the European Union shall apply the national procedures adjusted to be in conformity with the Directive 2014/24/EU on public procurement. According to this Directive, public procurement procedures are as follows:

1) open procedure;
2) restricted procedure;
3) competitive procedure with negotiation;
4) competitive dialogue;
5) innovation partnership;
6) negotiated procedure without prior publication.[25]

"There is a great need for contracting authorities to have additional flexibility to choose a procurement procedure, which provides for negotiations. Member States should be able to provide for the use of the competitive procedure with negotiation or the competitive dialogue in various situations where open or restricted procedures without negotiations are not likely to lead to satisfactory procurement outcomes. It should be recalled that use of the competitive dialogue has significantly increased in terms of contract values over the past years. It has shown itself to be of use in cases where contracting authorities are unable to define the means of satisfying their needs or of assessing what the market can offer in terms of technical, financial or legal solutions. This situation may arise in particular with innovative projects, the implementation of major integrated transport infrastructure projects, large computer networks or projects involving complex and structured financing."[26]

In Serbia, according to the Public Procurement Law, a public procurement contract is awarded in an open procedure or in a restrictive procedure as a rule. However, the public procurement contract may also be awarded in certain other, above mentioned procedures, provided that the requirements prescribed by this Law are met.

Pursuant to this Law, the contracting authority shall ensure that goods, services or works procured in public procurement are adequate by quality, value, purpose and intended use. Furthermore, the contracting authority shall ensure that the public procurement procedure is conducted and contracts are awarded within time limits and with minimum costs spent in conducting public procurement and implementing the contract.

Regarding the principle of ensuring competition, contracting authorities may not limit competition or prevent any bidder from participating in public procurement by unjustified use of the negotiated procedure or by using discriminatory requirements, technical specifications and criteria. In addition, contracting authorities shall set requirements for participation in the procedure in such a way that does not discriminate bidders and does logically relate to the subject-matter of public procurement.

Concerning the principle of proportionality, contracting authorities shall conduct public procurement in a manner proportionate to the subject-matter of public procurement and the objectives to be achieved. Moreover, criteria for qualitative selection of economic operators in public procurement procedures, technical specifications, contract award criteria and deadlines, as well as evidence, must be proportionate to the size, nature and complexity of a given public procurement and the resulting contract.

[24] See: Directive 2014/24/EU, Annex XII MEANS OF PROOF OF SELECTION CRITERIA
[25] See: Directive 2014/24/EU, Art. 26-32
[26] Directive 2014/24/EU, recital (42) in the preamble

6. Concluding Remarks

The diversity and complexity of construction activities have an impact on the complexity and specific characteristics of construction procurement. Construction activities are listed in Annex II of the European Union Directive on Public Procurement (Directive 2014/24/EU).

Accordingly, construction covers the following: construction of new buildings and works, restoring and common repairs; site preparation; building of complete constructions or parts thereof; civil engineering; general construction of buildings and civil engineering works (including bridges, long-distance pipelines, communication and power lines, urban pipelines, urban communication and power lines, architectural and engineering activities, project management for construction); construction of highways, roads, airfields and sport facilities; construction of water projects, building installation, building completion, etc.

Specific characteristics of construction procurement can be pointed out concerning bidding documents, requirements for participation in public procurement and conducting public procurement procedures. As a general rule, contracting authorities apply open or restricted procedures. In specific cases and circumstances, contracting authorities may award public contracts by a negotiated procedure without prior publication. In the case of innovative projects, the implementation of major integrated transport infrastructure projects, as well as projects involving complex and structured financing, contractors may apply a competitive procedure with negotiation or a competitive dialogue.

When it comes to Serbia, the strategic objectives of public procurement reform include complete harmonization of the Serbian legislation with the EU acquis in the field of public procurement and its effective implementation in practice. Activities in the process of harmonisation with the *acquis communautaire*s should be focused on specific issues such as: e-procurement; public procurement in the fields of water management, energy, transport and postal services, as well as public procurement in the field of defence and security.

References

DIRECTIVE 2014/24/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on public procurement and repealing Directive 2004/18/EC (Official Journal of the European Union L94, 28 March 2014)

DIRECTIVE 2014/25/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC (Official Journal of the European Union L94, 28 March 2014)

FIDIC. (1987). *Conditions of Contract for Works of Civil Engineering Construction*, FIDIC.

Joković, S. (2022). *Winning Public Procurement Contracts in Serbia Manual- Second Updated Edition.* Kobo. https://www.kobo.com/us/en/ebook/winning-public-procurement-contracts-in-serbia-second-updated-edition

Joković, S.(2022). *Public-Private Partnerships and Concessions in Serbia Manual-Second Updated Edition*. Kobo. https://www.kobo.com/us/en/ebook/public-private-partnerships-and-concessions-in-serbia-second-updated-edition

Joković, S.(2019). *Competition and Integrity in Public Procurement*. Kobo. https://www.kobo.com/us/en/ebook/competition-and-integrity-in-public-procurement

Joković, S. (2019). Competition and Serbian Public Procurement Policy. *European Procurement and Public Private Partnership Law Review*, Vol. 14, Issue 3, 174-179. DOI https://doi.org/10.21552/epppl/2019/3/6

Joković, S. (2019). Bid Rigging Analysis and Relevant Provisions in the Serbian Legislation. *World Competition Law and Economics Review*, Vol. 42, Issue 2, 237-252. ID:WOCO2019015

Joković, S. (2018). Characteristics of the Legal Framework for Serbian PPPs. *European Procurement and Public Private Partnership Law Review*, Vol. 13, Issue 2,.113-118. DOI https://doi.org/10.21552/epppl/2018/2/6

Joković, S (2016). Public Procurement Awarding Procedures, Incentives and Efficiency in Serbia. *European Procuremen and Public Private Partnership Law Review*, Vol. 11, Issue 4, 361-369. DOI https://doi.org/10.21552/epppl/2016/4/14

Joković, S. (2015). Analysis of the compliance of national legislation on public procurement with acquis communautaire (newDirective2014/24/EU). *Market,Money,Capital,* No. 1, (January-March),73-84.

Joković, S. (2015, 17 February).Equal treatment of all bidders [Paper Presentation].Regional conference on Progressive and Effective Opening of the CEFTA Public Procurement Market, Skopje, Republic of North Macedonia.

Joković, S. (2013).The reform of public procurement system. *Market, Money, Capital,* No.3, (July-September) 13-21.

Joković, S. (2010). *International market of capital projects and economic development*. Institute for Business Research MBA.

Joković, S. (2008).The rules of procurement and the Multilateral Development Banks with particular reference to the European Bank for Reconstruction and Development. *Conjunctural Trends of Serbia,* No. 8-9, 78-85.

Joković, S. (2006). Public procurement in Serbia-The Public Procurement Law amendments. *Conjunctural Trends of Serbia,* No.4, 78-81.

OECD. *Public Procurement Toolbox*. www.oecd.org/governance/procurement/toolbox/about/terminology

Rulebook on the Content of Tender Documentation in Public Procurement Procedures ("Official Gazette of the Republic of Serbia", No. 21/2021)

The Law on Public Procurement ("Official Gazette of the Republic of Serbia," No. 91/2019)

The Public Procurement Development Strategy in the Republic of Serbia for the period 2014-2018 ("Official Gazette of the Republic of Serbia," No. 71/2011)

Vukmir B. (1980). *Works contracts-International / Ugovori o izvođenju investicijskih radova- međunarodni*, Centar za informacije i publicitet.

World Bank. (1996). *Guidelines - Procurement under IBRD Loans and IDA Credits*. World Bank.

ASIAN INSTITUTE OF RESEARCH
Connecting Scholars Worldwide

The Asian Institute of Research
Engineering and Technology Quarterly Reviews
Vol.5, No.2, 2022: 46-49
ISSN 2622-9374

Fabrication of Multilayer Nanowires (Ag/Co/Zn) by Electro-Chemical Deposition in the Anodic Aluminum Oxide Template

Ibrahim Tawana[1], Hussein Aziz[2], Mohammad Dad Saay[3], Awaz Bromand[4]

[1] Department of Physics, Faculty of Natural Sciences, Bamyan University, Bamyan, AFG
[2] Department of Physics, Faculty of Natural Sciences, Bamyan University, Bamyan, AFG
[3] Department of Mathematics, Faculty of Natural Sciences, Bamyan University, Bamyan, AFG
[4] Department of Physics, Ghor institute of higher education, Ghor, AFG

Correspondence: Ibrahim Tawana, Assistant Professor, Department of Physics, Bamyan University.
Tel: 0093775948190. E-mail: ib.tawana@gmail.com

Abstract
In this article, multilayer nanowires (Ag/Co/Zn) were produced by electrochemical deposition in the form of anodic aluminum oxide. The electrochemical deposition method to produce nanowires are performed by three different methods. We have examined the pulsed periodic method, and we have managed to fabricate the nanowires of Ag/Co/Zn. Then, the produce nanowires are confirmed by the SEM and XRD analyses. Anodic nanoporous alumina with a thickness of 205 nm and a distance between pores of about 250 nm is produced by combining hard and soft anodization. Two-step anodization method including soft anodization and hard anodization was performed. These two anodizations were performed using 0.3 M oxalic acid as electrolyte at 0 degrees Celsius and applying voltages of 40 and 130 volts, respectively. Then the potential was reduced from 130V to 12V to thin the barrier layer. Multilayer nanowire arrays had been electrodeposited into the pores of anodic aluminum oxide (AAO) template. The electrochemical impedance spectroscopy has been carried out to study the in situ growth process of multilayer nanowires at different electrodeposition times.

Keywords: Multilayer, Anodize and Nanowires

1. Introduction

The synthesis and study of nanoscale materials have attracted much attention in recent years. One-dimensional nanostructures, including nanowires, nanorods, and nanotubes, have many amazing properties such as high density, high aspect ratio, and low threshold voltage in field emission (Baibich, et al., 1988). To obtain multi-layered nanowires, it was necessary to place metal pieces in AAO channels in order (Peng, Wu, & Hwang, 2013).One of the possibly least complicated wires fabrication method is electrodeposition (Torabinejad,

Aliofkhazraei, Assareh, Allahyarzadeh, & Rouhaghdam, 2017). Thermal decomposition of elements in the porous membranes (e.g. anodic aluminum oxide (AAO)) is also very powerful (Gong, Riemer, Kautzky, & Tabakovic, 2016); (Winkler, et al., 2008); (Szozstko, Orzechowska, & Wykowska, 2013); (Garcia, et al., 2014). Wires can also be obtained by deposition of elements in particular conditions on flat surfaces which were pre-structured by lithography, self-lithography, pre-deposition, oxidation, etc. This, however, often employs very sophisticated experimental setups Generally, a hard template containing nanometer-sized cylindrical pores is used as a membrane to synthesize multilayer nanowires, and the pores are filled with nanowire fragments of different elements (Schwarzacher & Lashmore, 1996) Anodic alumina films are known to have perpendicular holes normal to the film surface with a nanochannel density in the range 10^{11}–10^{13} cm−2 (Chaure, Stamenov, Rhen, & Coey, 2005).The electrodeposition is a simple and cheap method for the production of multi-layer nanowires by which we can control the aspect ratio of the nanowires (Mohanty, 2011). However, it is important to consider whether the deposition conditions can affect the quality and length of the obtained nanowires. One of the exciting achievements of the development of electrochemical deposition method is the production of multi-layer nanowires in the molds that are proposed by Piraux and Blondel almost simultaneously (Blondel, Meier, Doudin, & Ansermet, 1994)

2. Experimental

High-purity (99.999%) aluminum foil was cut to the desired sizes. Each sample was degreased in acetone and ethanol for 5 min in ultrasound cleanser and then washed with deionized water. To have a sample with a smooth and polished surface, it was electropolished at a potential of 20 V and current of 60 mA for 6 min in the electrolyte solution of 1:4 (v/v) perchloric acid in 99% ethanol. In order to fabricate a high ordered anodic aluminum oxide (AAO), two steps anodization method consisting mild anodize (MA) and hard anodize (HA) was done. MA and HA were performed by utilizing oxalic acid 0.3 M as an electrolyte at zero degree of centigrade and by applying 40 V and 130 V, respectively. Then for thinning of the barrier layer, the potential was decreased from 130 V to 12 V. The next part of research, the procession well is dawn in three step, at first we used solution 2.5g $AgNO_3$ and 4g H_3BO_3 in 100ml distilled water for Ag electrodeposition, second for cobalt electrodeposition $CoSO_2$, 0.3M solution were used and for third step the solution is 10.5g $ZnSO_27H_2O$ and 3.6g H_3BO_3 in 90ml distilled water 0.4M. Anodization and electrodeposition conditions are shown in Table.1.

Table 1: Anodization and electrodeposition conditions for (Ag/Co/Zn)

No	Type of material	Charge (C)	Reduction-Voltage (V)	Reduction-Time (ms)	Oxidation Voltage (V)	Oxidation-Time (ms)	Off-Time (ms)
1	Silver	0.2	14	5	14	5	**10**
2	Cobalt	0.2	14	5	14	5	**10**
3	Zinc	0.11	14	5	14	5	**10**

XRD characterization of Ag/Co/Zn nanowires is presented in Fig.1

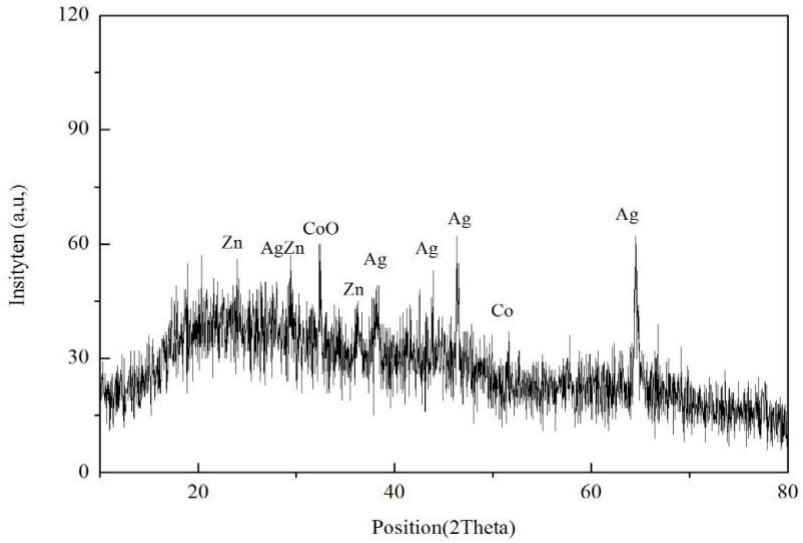


Figure 1: XRD of Ag/Co/Zn deposition on porous AAO template by applying alternative pulse electrodeposition.

Also, SEM image of the profile of fabricated Ag/Co/Zn nanowire is indicated in Fig. 2. It is possible to recognize from the profile of the structure that the nanowires are broken in the holes. It is clear that some parts of them are remained in the porous AAO.

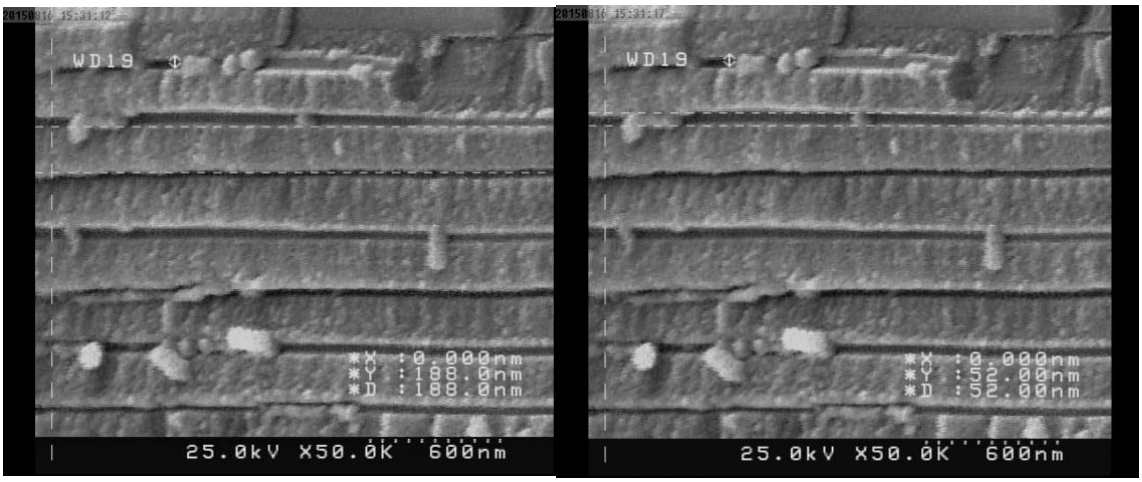


Figure 2: The profile of SEM image of Ag/Co/Zn.

3. Conclusions

In this research, using the anodization of aluminum with the High-purity (99.999%) aluminum foil by two steps anodize, mild anodonization and hard anodonization by 40 V and 130 V to produce alumina (Al_2O_3) nanopours templet then by thinning method, we produce roots in the barrier layer, the next step by electrodeposition method and Ag, Co and Zn salts, the multilayer nanowires fabricated in the nanopours.

References

Baibich, M. N., Broto, J. M., Fert, A., Van Dau, F. N., Petroff, F., Etienne, P., & Chazelas, J. (1988). Giant Magnetoresistance of (001)Fe/(001)Cr Magnetic Superlattices. *PHYSICAL REVIEW LETTERS, 61*, 2472. doi:https://doi.org/10.1103/PhysRevLett.61.2472

Blondel, A., Meier, J. P., Doudin, B., & Ansermet, J. P. (1994). Giant magnetoresistance of nanowires of multilayers. *Applied Physics Letters, 65*(23), 3019. doi:https://doi.org/10.1063/1.112495

Chaure, N. B., Stamenov, P., Rhen, F. M., & Coey, J. M. (2005). Oriented cobalt nanowires prepared by electrodeposition in a porous membrane. *Journal of Magnetism and Magnetic Materials, 290*(2), 1210-1213. doi:https://doi.org/10.1016/j.jmmm.2004.11.387

Garcia, J., Vega, V., Prida, V. M., Hernando, B., Barriga Castro, E. D., Resendez, R. M., & Iglesias, L. (2014). Template-assisted Co–Ni alloys and multisegmented nanowires with tuned magnetic anisotropy. *Application and Materals Science, 211*(5), 1041-1047. doi:https://doi.org/10.1002/pssa.201300731

Gong, J., Riemer, S., Kautzky, M., & Tabakovic, I. (2016). Composition gradient, structure, stress, roughness and magnetic properties of 5-500 nm thin NiFe films obtained by electrodeposition. *Journal of Magnetism and Magnetic Materials, 398*, 64-69. doi:https://doi.org/10.1016/j.jmmm.2015.09.036

Mohanty, U. S. (2011). Electrodeposition: a versatile and inexpensive tool for the synthesis of nanoparticles, nanorods, nanowires, and nanoclusters of metals. *Journal of Applied Electrochemistry, 41*, 257–270. doi:https://doi.org/10.1007/s10800-010-0234-3

Peng, C. H., Wu, T. Y., & Hwang, C. C. (2013). A Preliminary Study on the Synthesis and Characterization of Multilayered Ag/Co Magnetic Nanowires Fabricated via the Electrodeposition Method. *The Scientific World Journal, 2013*, 1-3. doi:https://doi.org/10.1155/2013/837048

Schwarzacher, W., & Lashmore, D. S. (1996). Giant magnetoresistance in electrodeposited films. *IEEE Transactions on Magnetics, 32*(4), 3133 - 3153. doi:10.1109/20.508379

Szozstko, B. K., Orzechowska, E., & Wykowska, U. (2013). Organophosphorous modifications of multifunctional magnetic nanowires. *Colloids and Surfaces B: Biointerfaces, 111*, 509-516. doi:https://doi.org/10.1016/j.colsurfb.2013.05.033

Torabinejad, V., Aliofkhazraei, M., Assareh, S., Allahyarzadeh, M. H., & Rouhaghdam, A. S. (2017). Electrodeposition of Ni-Fe alloys, composites, and nano coatings–A review. *Journal of Alloys and Compounds, 691*, 841-859. doi:https://doi.org/10.1016/j.jallcom.2016.08.329

Winkler, K., Zolopa, M. W., Oleksicka, M. M., Recko, K., Dobrzynski, L., Stork, J. R., & Balch, A. L. (2008). Variations in the crystalline deposits formed upon electrochemical oxidation of the anions, [Ir(CO)2X2]− (X = Cl, Br, and I). *Electrochimica Acta, 53*(24), 7288-7297. doi:https://doi.org/10.1016/j.electacta.2008.04.011

The Asian Institute of Research
Engineering and Technology Quarterly Reviews
Vol.5, No.2, 2022: 50-57
ISSN 2622-9374

A Study on the Assessment of Bridge Pier Shape to Minimize Local Scour

Md. Mohirul Islam Mohir[1], ABM Ashrafuzzaman Khan[2], Md. Kawsar[3], Md. Monzurul Hasan[4]

[1] Student, European University of Bangladesh, Email: planplusbd@gmail.com
[2] Student, European University of Bangladesh, Email: ashrafuzzaman019@gmail.com
[3] Student, European University of Bangladesh, Email: 291mdkawsar@gmail.com
[4] Senior Lecturer, European University of Bangladesh, Email: monzurul.hasan93@gmail.com

Abstract
Local Government Engineering Department (LGED) intends to construct a bridge over the river Shitalakhya on Kapasia (Lalon Bazar) to Bashgram GC via Panli GC via Horinaraynpur GC via Kushalibaha Hat road in the Kapasia Upazila of Gazipur District. The horizontal lay out of the bridge in UTM projection system at Left Bank (Dhandia Bottola Bazar) is 24°04'26.83"N & 90°37'52.64"E and at Right Bank (Raniganj Bazar) is 24°04'32.26"N & 90°38'03.54"E. Estimated Standard High Water Level is 7.520 mPWD, minimum vertical navigational clearance as per BIWTA is 7.620m and calculated deck height is 2.950m. Thus clear height of the bridge is 15.140 mPWD and crest of the deck level of the bridge at mid point is 18.090 mPWD. The pier scour depth has been calculated as per Manual on hydrologic and hydraulic design of bridges prepared jointly by Bangladesh University of Engineering and Technology (BUET) and Institute of Water Modeling (IWM) in 2008. Seven (7) methods as Breusers [1965], Laursen [1963], Neill [1987], Jain and Fischer [1980], Chitale [1988], Melville [1997] and Richardson & Davis [1995] have been applied for pier scour depth calculation among which Jain and Fischer [1980] method shows the highest scour depth. The present study shows the scour depth for different methods with different effective pier width for non-uniform pier instead of uniform pier.

Keywords: Equivalent Pier Width, Pier Scour, Initial Bed Level, Standard High Water Level (SHWL)

1. Introduction

Scour means the lowering of the river bed level by water erosions such that there is a tendency to expose the foundations of a bridge. Pier scour is the removal of soil particles around the pier and exposer of pile is the product of pier scour. Minimization of local scour around the bridge pier is very important for bridge construction with minimum cost. Non-uniform pier has been considered under this study. Pile dia size 0.7m to 1.5m has been considered for different pier scour calculation formulas with two raw facing and three raw facing pier.

Different studies have been conducted for reducing pier scour by Melville (1997), Melville and Coleman (2000), Al-Shukur and Obeid (2016), Muke and Bhosale (2015), Elsebaie (2013) and others. In the present study, a single

cylindrical pier has been considered as a non-uniform pier by using an equivalent pier diameter, b*. It has been calculated by the following formula:

$$b^* = (pm-1) \text{ X } S + 2 \text{ X } dp$$

Where, pm is the number of raw, S is the distance between pile and dp is diameter of the pile (Figure 1). The effective equivalent diameter depends on the position of the pile cap and the piles with respect to the initial bed level.

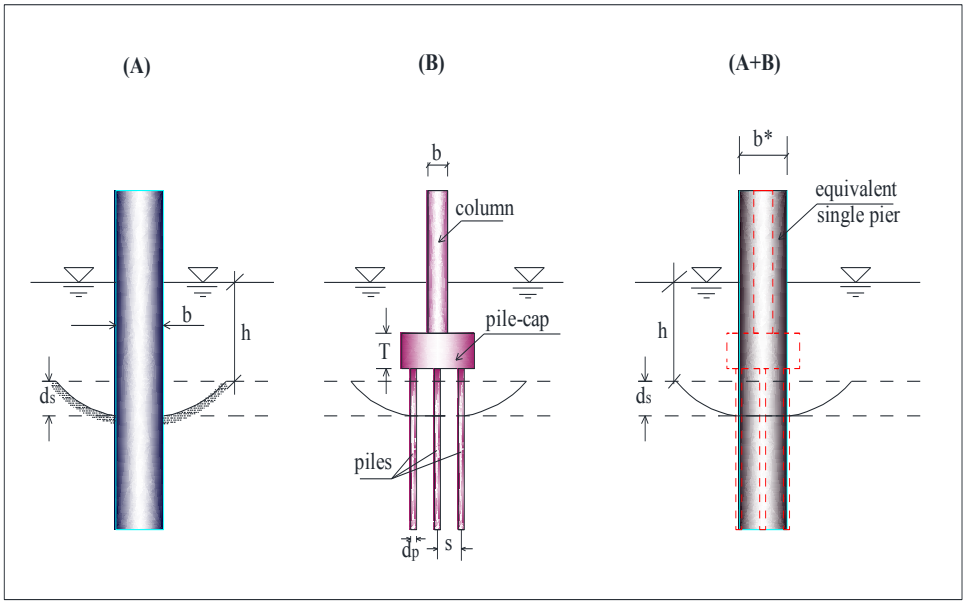


Figure 1: A Non-uniform Pier and Its Equivalent Pier

2. Objectives Of The Study

The objective of the study is to estimate the bridge pier scour for different pier scour calculation methods using equivalent pier diameter process. To know the change of pier scour for different diameter and arrangement of pile is the ultimate result of this study.

3. Literature Review

The methods developed for equivalent single pier by Melville and Coleman (2000), Richardson and Davis (2001), Coleman (2005) and Sheppard (2005) are considered. The basic mechanism causing at piers at the down flow at the upstream face of the pier and formation of vortices at the base. The approach flow velocity is reduced to zero at the upstream side of the pier which results in a pressure increase at the pier face. The associated pressures are highest near surface, where the declaration is greater and decrease downward. Due to this the pressure on the face of the pier also decreases accordingly forming a downward pressure gradient. The pressure gradient forces the flow down the face of the pier. The resulting down flow creates hole in the vicinity of the pier base (Figure 2).

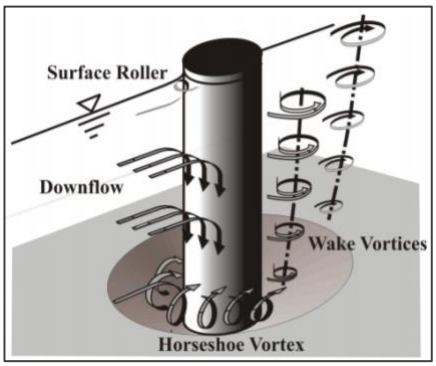


Figure 2: Flow and scour pattern at a circular pier, Melville and Coleman (2000)

Different factors affect the process of scour around bridge piers and the flow pattern. This study focused on the influence of the bridge piers shapes on minimizing the local scour. The shape of pier is one of the important factors that play an important role in the creation and the strength of the vortex system. The system of vortex consists of horseshoe vortex, wake vortex system, trailing vortex system and bow wave vortex (Chiew, 1984). There are two types of piers, uniform (simple) piers and non-uniform piers (complex). Uniform piers are piers having a constant section throughout their depth and non-uniform piers include piers of piled foundations, slab footing and tapered piers (Melville and Coleman, 2000). This study is limited to only non-uniform piers and their effects on the depth of local scour.

Al-Shukur and Obeid (2016) have conducted an experimental study of bridge pier shape to minimize local scour and found that rectangular pier has a maximum exposed area that's why scour depth is much higher than other shape. They concluded that the streamline shape is considered the best shape of piers that reduces the maximum scour depth by 60% as compared with rectangular shape. Another experimental study of local scour around circular bridge pier in sand soil has been conducted by Elsebaie (2013) and found that the depth of scour increases with time, however it was found that the rate of increase of scour depth was decreasing for a longer time interval. Rate of flow does affect the depth of scour, scour depth was more with higher flow rate.

4. Methodology

In this method, non-uniform pier has been considered as a single cylindrical pier by using an equivalent pier diameter, b*. This equivalent cylindrical pier is such that, for the same flow and sediment conditions, produces the same scour depth, ds, as the non-uniform pier. The effective equivalent diameter depends on the position of the pile cap and the piles with respect to the initial bed level. In the case of non-uniform pier with pile cap and pile below it (Figure 2), the effective pier diameter needs to be estimated by the following equation depending on the location of the pile cap.

$$b_e = b\left(\frac{h+Y}{h+b^*}\right) + b^*\left(\frac{b^*-Y}{b^*+h}\right)$$

b_e = Effective pier width
b_p = Pier width
b^* = Pile cap width
h = Hydraulic depth of flow
Y = Distance between the initial bed level and the top of the pile cap

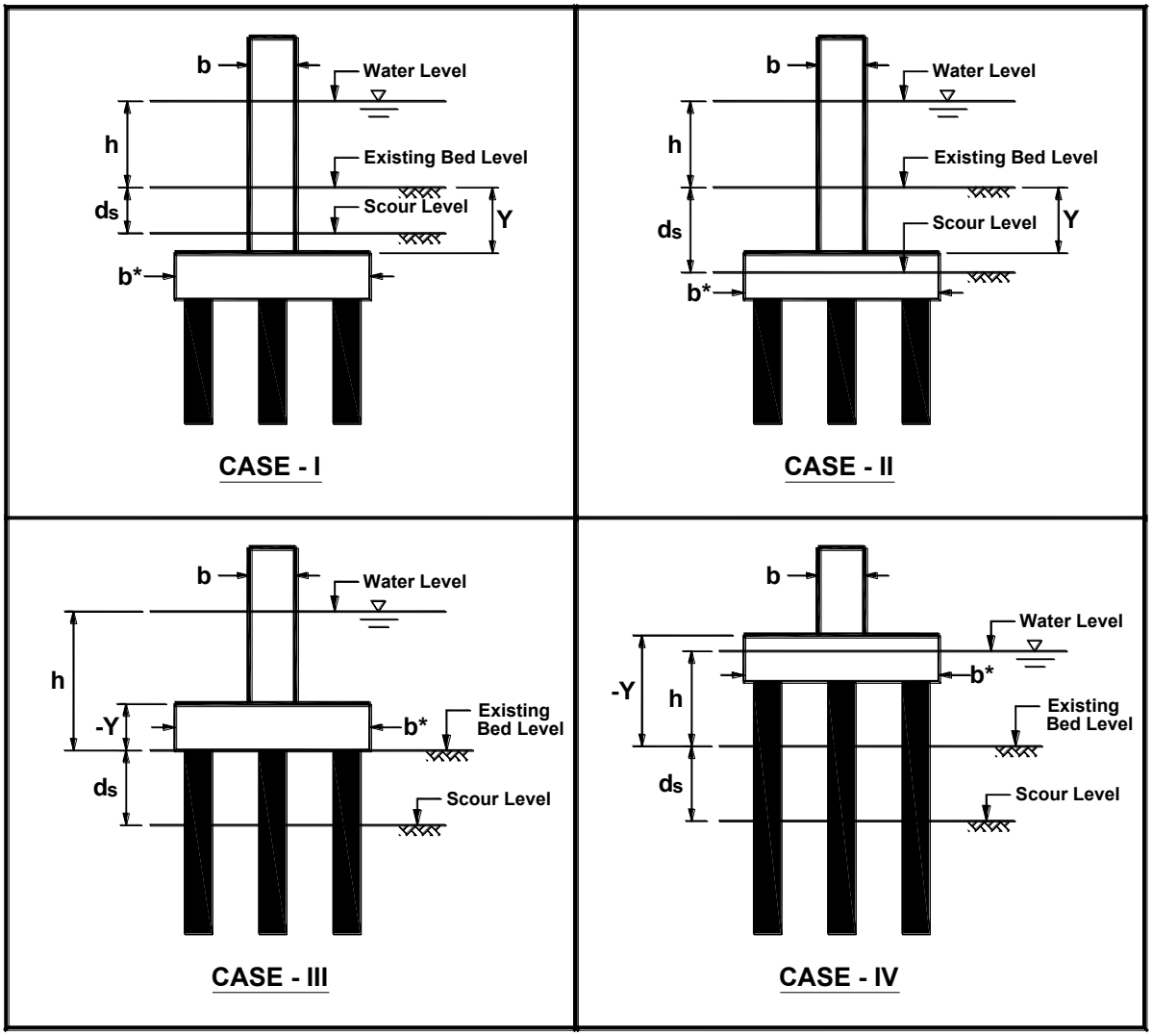


Figure 2: Potential Local Scouring with non-uniform Pier Shapes

In this study, only Case-III has been considered for scour depth calculation. From many available methods for the prediction of the maximum scour depth around piers, only some selected methods are discussed in Table 1.

Table 1: List of formulae considered for pier scour depth prediction.

Reference	Equation	Notes
Breusers [1965]	$\frac{d_s}{b_p} = 1.4$	For tidal flow
Laursen [1963]	At the threshold condition: $d_s / b_p = 1.34\left(h / b_p\right)^{0.5}$	applicable for clear-water scouring
Neill [1987]	At the threshold condition: $d_s / b_p = K_s$	K_s =1.5 for round nose and circular pier and =2.0 for rectangular piers
Jain and Fischer [1980]	At the threshold condition: $d_s / b_p = 1.86\left(h / b_p\right)^{0.5}$	applicable for clear-water scouring condition

Chitale [1988]	At the threshold condition: $d_s / b_p = 2.5$	applicable for clear-water scouring condition
Melville [1997]	At the threshold condition: $b_p/h<0.7$: $d_s / b_p = 2.4$ $0.7<b_p/h<5$: $d_s / b_p = 2(h / b_p)^{0.5}$ $b_p/h>5$: $d_s / b_p = 4.5(h / b_p)$	the shape correction factors for square nosed and sharp nosed are 1.1 and 0.9, respectively
Richardson and Davis [1995] (HEC-18)	At the threshold condition: $d_s / b_p = 2 * K_s K_\theta K_3 K_4 (h / b_p)^{0.35} * Fr^{\wedge 0.43}$	the shape correction factors for square nosed and sharp nosed are 1.1 and 0.9, respectively. Applicable for tidal and clear water

5. Selection of Study Area

Local Government Engineering Department (LGED) intends to construct a bridge over the river Shitalakhya on Kapasia (Lalon Bazar) to Bashgram GC via Panli GC via Horinaraynpur GC via Kushalibaha Hat road in the Kapasia Upazila of Gazipur District. Kapasia Upazila has an area 356.98 sq km is located between 24°02' and 24°16' north latitudes and between 90°30' and 90°42' east longitudes. It is bounded by Gaffargaon and Pakundia Upazila on the north, Kaliganj, Shibpur and Polash Upazilas on the south, Monorhardi Upazila on the east and Sreepur Upazila on the west. Main rivers are Old Brahmaputra, Shitalakhya and Banar; Buri Beel, Machha Beel and Nail Beel are notable water bodies.

The Shitalakhya river originates from old Brahmaputra river located at Labutola Union of Monohordi Upazila under Narshingdi District and meets with Dhaleswari river located at Kalagachiya Union of Bandar Upazila under Narayanganj District. At present time this river carries low discharge. Movement of different types of vessels are existed almost all the year round and all most no erosion is existed. Famous River Port Narayanganj is situated in the shore of this river. Bangladesh Inland Water Transport Authority (BIWTA) has been declared its Class III Navigational Route for this river.

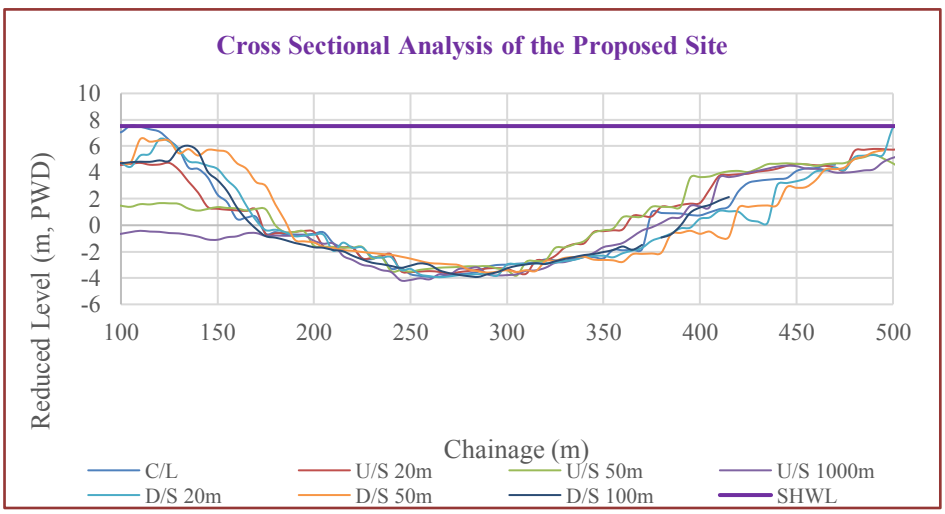


Figure 3: Cross-Sectional Analysis at Proposed Project Site

Kapasia Upazila has moderate level of road transportation facilities. It has RHD regional highway as well as LGED road network. This Upazila is located within North-Central Hydrological Region of Bangladesh. The mean annual rainfall of the study area is about 2582 mm. The bridge site is located in the Agro-ecological Zone 28 i.e. Madhupur Tract. This is a region of complex relief and soils developed over the Madhupur Clay. The soil type at Kapasia

Upazila near the study site is Deep Red-Brown Terrace Soils which is mainly occur on level to rolling relief on the Madhupur Tract. The bridge site is located in zone-II of the earthquake zones which is a zone of medium seismic risk with a basic seismic co-efficient of 0.05.

Figure 4: Location of Project Area

6. Results

Scour depth under before said seven methodologies have been calculated for different effective pier width with respect to different pile diameter. The outcome of the findings are presented in Table 2 as integrated outcome and Figure 5 and Figure 6 for 3 flow facing row and 2 flow facing row respectively.

Table 2: Summary of Scour Depth for Channel Pier

Pile Dia (m)	Flow Facing Pile Row Number		Effective Pier Width, b_e (m)	Scour Depth from Initial Bed Level (m) [IBL = -3.00 mPWD]						
				Breusers [1965]	Laursen [1963]	Neill [1987]	Jain and Fischer [1980]	Chitale [1988]	Melville [1997]	Richardson and Davis (HEC-18)
1.50	3		8.245	11.542	12.656	12.367	17.567	20.611	17.001	12.971
1.50	2		4.927	6.898	9.784	7.391	13.581	12.318	10.643	12.101
1.20	3		6.243	8.740	11.013	9.364	15.287	15.607	13.485	12.493
1.20	2		3.855	5.397	8.654	5.782	12.013	9.637	8.327	11.706
1.00	3		5.029	7.040	9.884	7.543	13.720	12.572	10.862	12.134
1.00	2		3.233	4.526	7.925	4.849	11.000	8.082	6.982	11.431
0.90	3		4.467	6.254	9.316	6.701	12.931	11.168	9.649	11.942
0.90	2		2.955	4.136	7.577	4.432	10.517	7.387	6.382	11.293
0.80	3		3.942	5.519	8.751	5.913	12.147	9.855	8.515	11.742
0.80	2		2.702	3.782	7.245	4.053	10.057	6.754	5.836	11.158
0.70	3		3.458	4.841	8.197	5.187	11.377	8.645	7.469	11.536
0.70	2		2.477	3.467	6.937	3.715	9.628	6.192	5.349	11.027

	
2 Row Facing Pile (Gorib Saha Bridge, Magura)	3 Row Facing Pile (Tikkar Char Bridge, Cumilla)

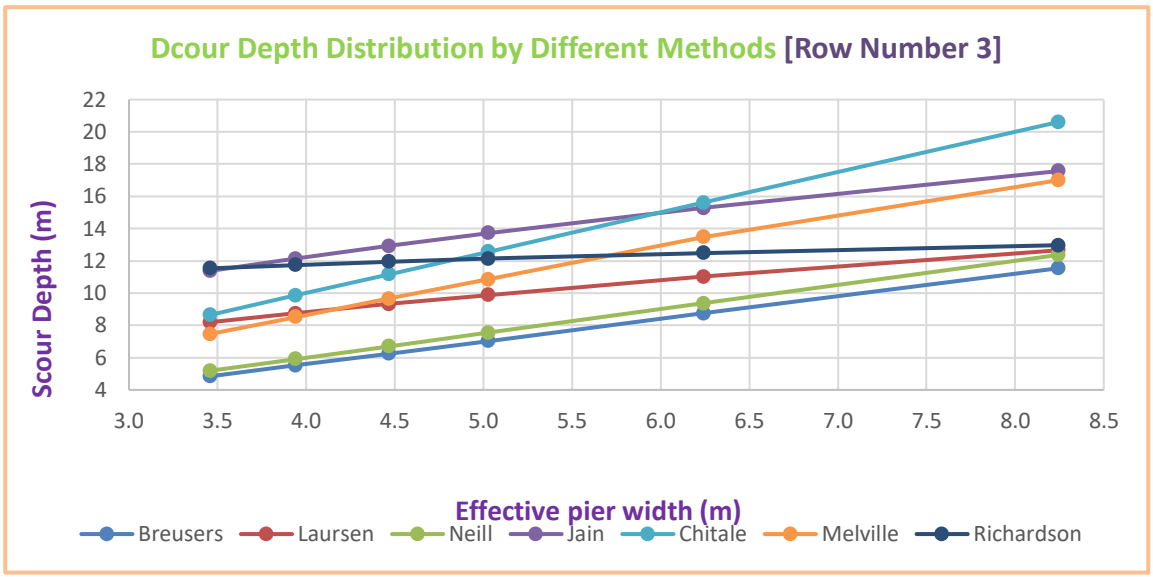


Figure 5: Scour depth for different effective pier width under 3 flow facing row

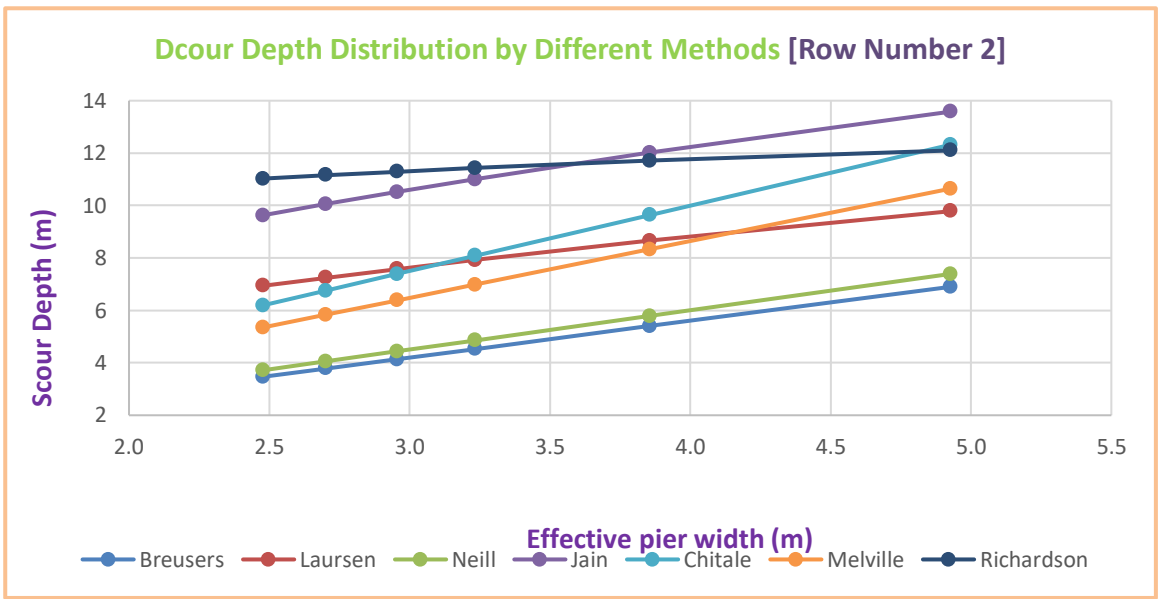


Figure 6: Scour depth for different effective pier width under 2 flow facing row

From Table 2 and Figure 5 and Figure 6, it is reveals that scour depth is 128% higher compare with 0.70m to 1.50m pile diameter for 3 flow facing row under the Method of Melville (1997). On the other hand for 2 flow facing row under the Method of Melville (1997), scour depth is 99% higher compare with 0.70m to 1.50m pile diameter. Arrangements of piles also affect the pile scouring. Existing bed level with respect to pile cap, structural arrangement of pile position and bed material characteristics affect the pier scour.

7. Conclusion

From scour depth calculation under different effective pier width, it is concluded that scour depth depends on the structural arrangement of bridge pier for the same discharge and same velocity in the proposed bridge river channel.

References

Chiew, Y.M., and Melville, B.M. (1987), Local scour around bridge piers, J. Hydraul. Res., 25(1), 15-26.

Melville, B.W. (1997), Pier and Abutment Scour, Integrated Approach, Journal of Hydraulic Division, ASCE 123, pp 237-243.

Melville, B.W., and Coleman, S.E. (2000), Bridge Scour, Water Resources Publications, LLC, Highlands Ranch, Colorado, USA.

Richardson, E.V. and Davis, S.R. (2001), Evaluating scour at bridge-Forth Edition, Hydraulic Engineering Circular No. 18, Publication No. FHWA NHI 01-001, U.S. Department of Transportation, USA.

Coleman, S.E. (2005), Clearwater local scour at complex pier, Journal of Hydraulic Engineering, ASCE, 131 (4), 330-334.

Sheppard, D.M. (2005), Bridge Scour Manual, Florida Department of Transportation, Florida.

Elsebaie, I.H. (2013), An Experimental Study of Local Scour Around Circular Bridge Pier in Sand Soil, International Journal of Civil Engineering & Environmental Engineering, Volume 13, Issue 01, February 2013.

Muke, P.R., and Bhosale, T.D. (2015), Local Scour and its Reduction by using Splitter Plate, International Journal of Science and Research, Volume 4, Issue 9, September 2015.

Al-Shukur, A.K., and Obeid, Z.H. (2016), Experimental Study of Bridge Pier Shape to Minimize Local Scour, International Journal of Civil Engineering and Technology, Volume 7, Issue 1, Jan-Feb 2016, pp. 162-171.

ASIAN INSTITUTE OF RESEARCH
Connecting Scholars Worldwide

The Asian Institute of Research
Engineering and Technology Quarterly Reviews
Vol.5, No.2, 2022: 58-64
ISSN 2622-9374

Synthesis and Characterization of Benzofuranone and its Derivatives

Mohammad Ali Nasiri[1], Abdulraouf Rashid[2] ,Bonyad Ali Moin[3], Azizullah Yosufi[4], Ismael Ahmadi[5], Mohammad Haidar Mosavi[6]

[1] Department of chemistry, faculty of natural sciences, Bamyan University, Bamyan, Afghanistan.
Email: Mhd.ali.nasiri@gmail.com
[2] Department of chemistry, faculty of natural sciences, Bamyan University, Bamyan, Afghanistan.
Email: abd.rauofrashid@gmail.com
[3] Department of chemistry, faculty of natural sciences, Bamyan University, Bamyan, Afghanistan.
Email: moinbamyan@gmail.com
[4] Department of chemistry, faculty of natural sciences, Bamyan University, Bamyan, Afghanistan.
Email: Email: yosofi88@gmail.com
[5] Department of chemistry, faculty of natural sciences Kabul Education University, Kabul, Afghanistan.
Email: ismelahmadi100@gmail.com
[6] Department of chemistry, faculty of natural science, Bamyan University, Bamyan, Afghanistan.
Email: saidhaidarmosavi1980@gmail.com

Abstract
In this experiment a mixture of salicylaldehyde (2 mmol), 4-chlorophenacyl bromide (2 mmol) and potassium tertiary butoxid (T-BuOK) (2mmol) in 10ml of Dichlorometane (DCM), containing molecular sieves was reflexed at 30C^°for 3 hours. Progress of the reaction was monitored by Thin layer chromatography (TLC) using hexane: ethyl acetate (8:2) mixture as mobile phase. After the completion of the reaction, the reaction mixture was washed with 10 % HCl solution followed by water. The organics were dried over anhydrous sodium sulfate. The yellow solid was obtained disolventizing in a rotary evaporator at room temperature affords benzofuran-2-yl (4-chlorophenyl) methanone. Benzofuranone (0.60 ml, 5 mmol) with substituted anilines (5 mmol) in round bottom flasks was refluxed in 15 ml methanol at 40C^° for 3 hours in the presence of 1.5 ml glacial acetic acid. In each case, the precipitated base was filtered off, recrystallized from absolute ethanol and dried in vacuum desiccators. The (Z)-N-(benzofuran-2-yl (4-chlorophenyl) methylene) aniline was obtained.

Keywords: Salicylaldehyde, TLC, DCM, Mobile Phase, Anhydrous Sodium Sulfate and Reflux

1. Introduction

The second half of last century has witnessed an enormous progress in organic synthesis as a consequence of the advent of innovative concepts with high predictable power and the development of new strategies and technologies culminating in the preparation of numerous natural and unnatural products of great complexity.

Formidable goals were achieved owing to the continuous efforts in the search for new reagents and methods, particularly those allowing one to assemble molecular building blocks via chemically efficient and stereo selective carbon-carbon bond-forming reactions (Vertuani, *et al*. 2004). At present, research in this field is even more actively promoted by the interplay of organic chemistry and various disciplines of life science such as biology, pharmacology, and medicine that are posing a pressing demand for natural products and synthetic analogues in meaningful scale and high purity. Although a great deal of new reagents and catalysts have been formulated as the result of profitable studies in organometallic chemistry (Jumbam, 2011).

2. Experimental

2.1. Materials and methods

A brief description of the solvents and reagents used here the analytical procedures followed, different physio-chemical techniques like TLC, melting point, IR, ^{1}HNMR and mass spectroscopic are employed for the characterization of the synthesized compounds those presented here (Collin, 2007).

2.2. Organic solvents

The organic solvents like ethanol, n-hexane, ethyl acetate (E-Merck), were of analytical reagent grade. Distilled water-double distilled water by quartz distillation unit (Harman, 1992).

2.3. Reagents

All the chemical reagents were obtained from the standard commercial sources unless otherwise indicated. DPPH (Sigma Aldrich), anhydrous sodium sulphate (Ranbaxy), salicylaldehyde, phenacyl bromides (E-Merck), sulfonyl chlorides (Mc Murry, 1989).

2.4. Analytical techniques

Thin-layer chromatography (TLC) was the method used to assess the reactions and the purity of the product compound. In this we used the TLC aluminium sheets-silica gel 60 F254 was purchased from Merck. The plates were developed using n-hexane: ethyl acetate (8:2) as mobile solvent. The spot was located by exposing the TLC plates to iodine vapours (Lenoir D, 1989).

Column chromatography was performed by using activated silica gel [60-120 mesh] packed onto the glass column [450 X 40 mm] with methanol as solvent. The crude product was loaded and eluted using mixture of n-hexane: ethyl acetate (8:2). The fractions were collected separately and active fraction was concentrated by using rota evaporator (Chittimalla, et. all. 2008).

2.5. Instrumentation

Melting points of the compounds were determined using SELACO-650 and Veego VMP-III model hot stage melting point apparatus and are uncorrected.

Identification and structure elucidation of newly synthesized compounds under study was carried out by using various spectroscopic techniques such as IR, ^{1}HNMR, mass and elemental analysis (Ledoussal, 1987).

An instrument of FT-IR021 model was used for recording IR spectra of the synthesized compounds. About 2-3 mg of compound was prepared as KBr pellet and the IR spectra were recorded.^{1}HNMR spectra were recorded on Joel GSX 400,400 MHz, spectrophotometer using $CDCl_3$ and DMSO-d_6 as solvents with tetramethylsilane (TMS) as internal standard. Mass spectra of the synthesized compound were obtained using a Q-TOF Waters Ultima instrument (No-Q-Tof GAA 082, Water Corporation, Manchester, UK) fitted with an Electron spray ionization (ESI) source (Dupont, 1999). The data acquisition software used was Version 4.0. Elemental analysis

was carried out on elemental Vario EL instrument. Oxygen was used for combustion and Helium as the mobile phase (Inghaml; Dewick. 1978).

3. General procedure for synthesis of benzofuranone derivatives IV (a-d)

Benzofuranone (0.6 ml, 5mmol) with substituted anilines (5 mmol) in round bottom flasks was refluxed in 15ml methanol at $40C^{\circ}$ for 3 hours in the presence of 1.5 ml glacial acetic acid. Progress of the reaction was monitored by Thin layer chromatography (TLC) using hexane: ethyl acetate (8:2) mixture as mobile phase. After the completion of the reaction, the reaction mixture was washed with 10 % HCl solution followed by water. The organics were dried over anhydrous sodium sulfate. The yellow solid was obtained disolventizing in a rotary evaporator at room temperature affords benzofuran-2-yl (4-chlorophenyl) methanone. In each case, the precipitated base was filtered off, recrystallized from absolute ethanol and dried in vacuum desiccators (Koenigkramer, 1980).

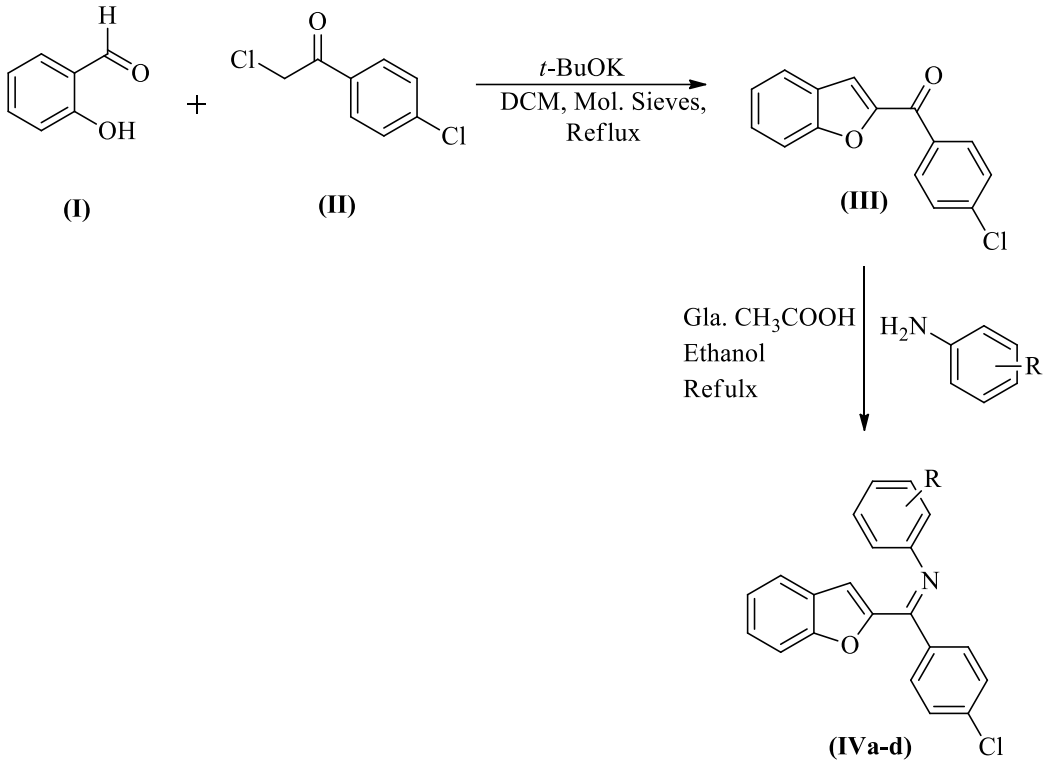
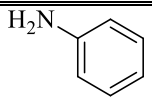
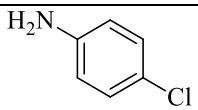
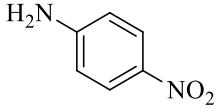
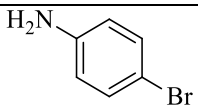


Figure 1: Reaction protocol for the synthesis of benzofuranone derivatives via IV(a-d)

Table 1: Chemical structure, yield and melting point of synthesized derivatives IV(a-d)

Compounds No	R-NH_2	Yield (%)	Melting Point (^{o}C)
Iva		70	107-109
IVb		76.5	210-212
IVc		75	192-198
IVd		72.4	188-189

(Z)-N-(benzofuran-2-yl(4-chlorophenyl) methylene) aniline (IVa).

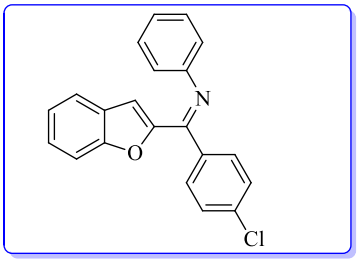


Figure 2: (Z)-N-(benzofuran-2-yl(4-chlorophenyl) methylene) aniline (IVa).

Brown solid, Spectroscopic analysis: IR (KBr)ν_{max}(cm^{-1}): 3132-2966 (Ar-CH), 1628 (C=N); ^{1}H NMR (DMSO-d_6 400 MHz) δ ppm: 6.93-7.90 (m, 14H, Ar-H), MS (ESI) m/z: 331.08 (M^+); Anal.calcd. for $C_{21}H_{14}ClNO$: C, 76.02; H, 4.25; N, 4.22; found: C, 76.09; H, 4.18; N, 4.20 %.

(Z)-N-(benzofuran-2-yl(4-chlorophenyl) methylene)-4-chloroaniline (IVb).

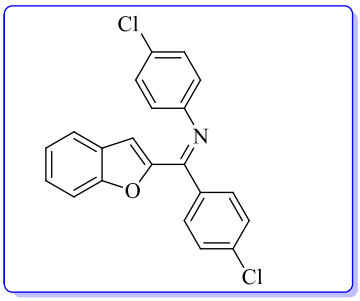


Figure 3: (Z)-N-(benzofuran-2-yl(4-chlorophenyl) methylene)-4-chloroaniline (IVb).

Brown solid, Spectroscopic analysis: IR (KBr)ν_{max}(cm^{-1}): 3130-2960 (Ar-CH), 1625 (C=N); ^{1}H NMR (DMSO-d_6 400 MHz) δ ppm: 6.90-7.92 (m, 13H, Ar-H), MS (ESI) m/z: 365.04 (M^+); Anal.calcd. for $C_{21}H_{13}Cl_2NO$: C, 68.87; H, 3.58; N, 3.82; found: C, 68.87; H, 3.55; N, 3.76 %.

(Z)-N-(benzofuran-2-yl(4-chlorophenyl) methylene)-4-nitroaniline (IVc).

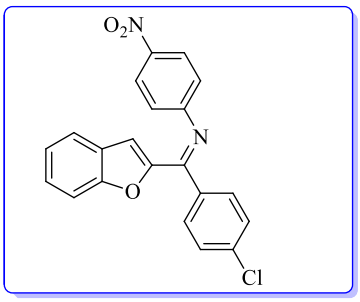


Figure 4: (Z)-N-(benzofuran-2-yl(4-chlorophenyl) methylene)-4-nitroaniline (IVc).

Orange solid, Spectroscopic analysis: IR (KBr)ν_{max}(cm^{-1}): 3135-2968 (Ar-CH), 1620 (C=N); ^{1}H NMR (DMSO-d_6 400 MHz) δ ppm: 6.85-7.90 (m, 13H, Ar-H), MS (ESI) m/z: 376.06 (M^+); Anal.calcd. for $C_{21}H_{13}ClN_2O_3$: C, 66.94; H, 3.48; N, 7.43; found: C, 66.83; H, 3.50; N, 7.46 %.

(Z)-N-(benzofuran-2-yl(4-chlorophenyl) methylene)-4-bromoaniline (IVd).

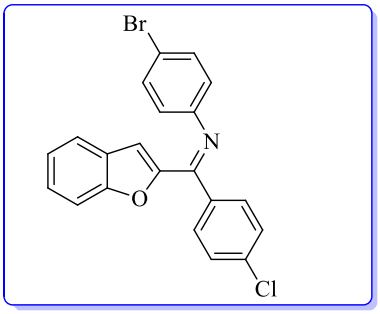


Figure 5: (Z)-N-(benzofuran-2-yl(4-chlorophenyl) methylene)-4-bromoaniline (IVd).

Black solid, Spectroscopic analysis: IR (KBr)ν_{max}(cm^{-1}): 3130-2970 (Ar-CH), 1620 (C=N); ^{1}H NMR (DMSO-d_6 400 MHz) δ ppm: 6.85-7.92 (m, 13H, Ar-H), MS (ESI) m/z: 408.99 (M^+); Anal.calcd. for $C_{21}H_{13}ClBrNO$: C, 61.41; H, 3.19; N, 3.41; found: C, 61.43; H, 3.20; N, 3.46 %.

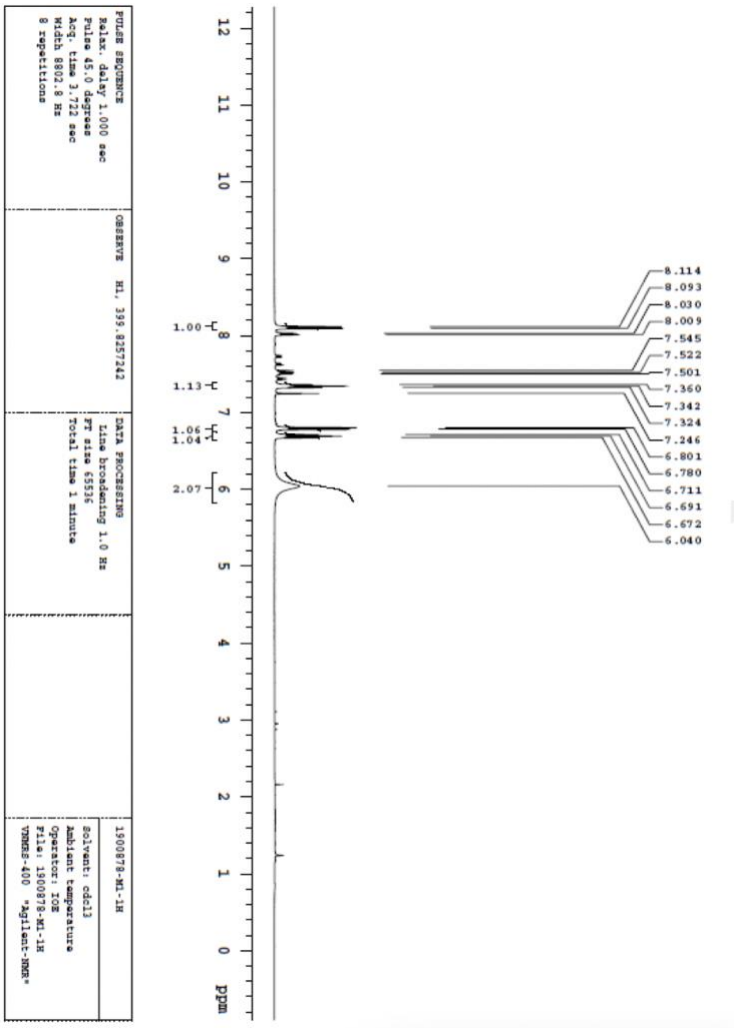


Figure 6: ^{1}H NMR spectra of compound (IVa).

4. Results and discussions

Benzofuranone was first synthesized by **Perkin** from counmarin Ketoesters derived from the acylation of O-hydroxyacetophenone with aliphatic as well as aromatic acid chlorides undergo intramolecular cyclization in the presence of low-valent titanium to afford benzofuranone in good yields. Benzofuranone derivatives are known to possess important biological properties. Substituted benzofuranone find application such as of fluorescent

sensor, antioxidants, brightening agents, a variety of drugs were reported in other field of chemistry and agriculture.

In this present work, a series of four new compounds were synthesized. **Figure 1** illustrates the way used for the preparation of target molecules. As a starting material salicylaldehyde is used to synthesize series of benzofuranone derivatives. The synthetic route involves, initially, o-alkylation of salicylaldehyde with phenacyl chloride in the presence of *t*-BuOK as base furnished o-alkylated aldehyde derivative, which subsequently generates enolate anion undergoing intramolecular cyclocondensation reaction that afforded benzofuranone. Further the compound reacts with different substituted anilines to obtained **(IVa-d)**. The structural synthesized compounds were confirmed by IR, ^{1}H NMR, mass spectra and elemental analysis.

5. Conclusion

Benzofuran is a heterocyclic compound consisting of fused benzene and furan ring. This colourless solid is a component of coal tar. Benzofuran is the "parent" of many related compounds with more complex structures. For example, psoralen is a benzofuran derivative that occurs in several plants. Benzofuran is extracted from coal tar. It is also obtained by dehydrogenation of 2-ethyl phenol.

Benzofuran and its derivatives have attracted much attention in medicinal chemistry for their wide range of various biological activities, including insecticidal, fungicidal, antimicrobial and antioxidant properties. Benzofuran compounds on the promising leads for the design of more efficient antimicrobial agents.

In the present investigation, I have reported the synthesis of benzofuranone derivatives via coupling of substituted anilines by choosing proper experimental conditions. Synthesized compounds were characterized by various analytical and spectral studied.

References

Adile Ayati., Saeed Emami ., Ali Asadipour c., 2014 *European Journal of Medicinal Chemistry*.

AG Shadia; S Amira; Abd El-All; Mohammed; IED Hoda. *Bioorg MedChemLett*. 2009, 19, 2420-2428.

Boger, D. L.; Weinreb, S. N. *Hetero Diels–Alder Methodology in Organic Synthesis*; Academic: New York, 1987.

B Rajeeva; Srinivasulu; SHantakumar. *E J Chem*. 2009, 6, 775-779.

B Ledoussal; A Gorgues; A Le Coq. Tetrahedron. 1987, 43, 5841.

Corey, E. J.; Cheng, X.-M. *The Logic of Chemical Synthesis*; Wiley: New York, 1989.

C Mechelle. Lippinwtt's Illustrated reviews: *pharmacology* (3rd edn). Lippincott Williams and Wilkins, U.S.

Dekkers, J. C., L. j. P. van Doornen, and Han C. G. Kemper. *sportsMed* 1996, 213-238.

D Lenoir. Synthesis. 1989, 12, 883.

Dekkers, J. C, L. J. P. Sports 1996, Med 21, 213-238.

DB Aruna Kumar; GK Prakash; MN Kumarasamy; BP Nandheswarappa; BS Sheringara. *Indian J Chem*. 2007, 46B, 336-343.

Eicher, T; Hauptmann, S. The *Chemistry of Heterocycles*: Structure, Reactions, Synthesis and Applications. 2nd edition. 2003. Wiley-VCH

F Messina; M Botta; F Corelli; C Mugnaini. Tetrahedron Lett. 1999, 40, 7289.

Gerd Colllin, Hartmut Hoke "*Benzofurans*" in Ullmann's encyclopedia of Industrial Chemistry, 2007, Wiley-VCH

Gerd Collin, HartmutHoke "Benzofuran" in *Ullmann'sencyclopedea of industrial Chemistry*, 2007, Wiley-VCH.

GerdCollin, Hartmut Hoke" Benzofurn" in Ullmann *'sencyclopedia ofIndustrial Chemistry*, 2007, Wiley-VCH.

GK Nalan; B Kadriya; T Yagmur; U Umit; D Seref. Eur J *Med Chem*.2006, 41, 651.

GL Pessini; BPD Filho; CV Nakamura; Diogenes Aparicia Cortez. Antibacterial activity of extracts and neolignans from piper regnillii (Miq). C. DC. Var. Pallescens (C. DC) Yunck, Mem Inst. Oswaldo Cruz, Rio dejaneiro. 2003, 98, 1115-1120.

Habermann, J.; Ley, S. V.; Smits, R. *J. Chem. Soc., Perkin Trans*. 1999, 1, 2421.

Harman D. Annals of New york Academy of Sciences, 1992, 673: 123-141.

HS Joshi; Kh popat; KS Nimavt. Indian J *Heterocycle Chem*. 2003, 12, 225-228.

I Hayakawa; R Shioya; T Agatsuma; H Furukawa; S Naruto; Y Sugano. *Bioorg Med ChemLett*. 2004, 14, 455-458.

JE Mc Murry. *Chem Rev*. 1989, 89, 1513.
JL Inghaml; PM Dewick. Photochemistry. 1978, 17, 534.
Kummetha Indrasena Reddy, Konduri Srihari b. 2014 *Bioorganic &Medicinal Chemistry.*
Kaczmarski, M.J. Wojicicki, L. Samochowiee, T Dutkiewicz, and Z, Sych. Pharmazie 1999, 54, 303-306.
K Ishibashi; K Nakajima; Y Sugioka; M Sugiyama; T Hamata; H Horikoshi; T Nishi. *Chempharma Bull*. 1999, 47, 226.
K Manna; YK Agarwal. *Bioorg Med ChemLett*.2009, 19, 2688.
LVG Nargund; BM Gurupadayya; AN Nagappa; B Shivakumar; E Jayachandran. Indian J *Heterocycle Chem*. 1998, 7, 213-216.
MMJ Vijay Kumar. KV Jayadevaiah; TS Nagaraja; DR Bharathi; H Shameer; E Jayachandran; GM Sreenivasa; *Arch Pharm Sci Res*. 2009, 1, 31-39.
M Samia; SA Rida; M El-Hawash; T Hesham; Y Fahmyl; AA Hazzaa; MM Mostafa MM. *Arch Pharm Res* 2006, 29, 826-833.
M Ghelardoni; V Pestellini; SP Del. Ger Pat Offen. 1981, 3.
N.C. Desai., Nayan Bhatt., 2013 *European Journal of Medicinal Chemistry.*
ND Jumbam; MPI Yedwa; W Masamba. *Bull Chem* Soc Ethiop. 2011, 25, 157, 160.
Oter, O.; Ertekin, K.; Kirilmis, C.; Koca, M.; Ahmedzade, M. *Sens. Actuators B: Chem.* 2007, 122, 450.
P Cagniant; D Cagniant. Adv *Heterocycle Chem*. 1975, 18, 337.
Rickborn, B. *Advances in Theoretically Interesting Molecules*; Thummel, R. P., Ed.; JAI: Greenwich, CT, 1989, 1.
Rodrigo, R. *Tetrahedron* 1988, 44, 2093.
R Dupont. Synthesis.1999, 9, 1651.
R Dupont; P Cotelle. Tetrahedron. 2001, 57, 5585.
R Dupont; P Cotelle. Tetrahedron Lett. 2001, 42, 597.
RE Koenigkramer; H Zimmer. *J Org Chem*. 1980, 45, 3994.
R Govindarajan; HJ Jameela; AR Bhat. Indian J *Heterocycle Chem*. 2003, 12, 229-232.
SK Chittimalla; TC Chang; TC Liu; HP Hsieh; CC Liao: Tetrahedron. 2008, 64, 2586.
S Lourdes; T Marta; U Eugenio; T Carmen; L Belen. *Eur J Pharm Sci*. 1999, 7, 161-166.
Sies H. " Oxidative stress: Oxidants and antioxidants" (PDF). Exp Physical 1997, 82, 291.
U Alejandro; C Marcos; Rezende; M Carolina; V Loretta. Molecules. 2008, 13, 882-891.
Vertuani S, Angusti A, Manfredini S. "The antioxodants and pro-antioxidants network: and overview"., Curr Pharm Des 2014, 10, 1677-94.
Varki, A. *Glycobiology* 1993, *3*, 97. (b) Dwek, R. A. *Chem. Rev.* 1996, *96*, 683.
Vertuani S, Angusti A, Manfredini S. Curr pharm Des 2004, 10, 1677.
Wege, D.; *Advances in Theoretically Interesting Molecules*; Thummel, R. P., Ed.; JAI: Greenwich, CT, 1989, 4, 1.
WH Perkin XXIX. *J Chem* Soc. 1870.