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Western-Themed Towns in China: Structural Analysis of Forgeries

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Abstract
Throughout daily life, most of us are introduced to a variety of architectural themed elements, such as replicas or forgeries that are far from their original birthplace. We often see them in hotels, shopping malls, amusement parks, in various sizes, shapes, and quantities. We experience them in passing, in the short term. However, what happens when such elements are afforded a great opportunity and freedom? Among various things, we can get themed towns. Life in China introduced me to this architectural phenomenon, through the concept of Western-themed towns, which deserves research with the purpose of discovering the fundamental ideas upon which it is based. Through various analyses, this research has covered many structural elements that make up these themed towns. Therefore, the search for a new identity of Chinese architecture, with the help of various cultural fragments, has been found to be crucial in creating the space for the birth of this phenomenon, which has many unique features.

Keywords: Architecture, China, Fake, Forgery, Replica, Mimicry, Copycat, Kitsch

1. Aims

The first aim of this research paper is to show the culture of 'copying' in China, why replicas of famous architectural works from Western countries have appeared there, and to discover the fundamental ideas and reasons behind it. The second aim of this research paper is to show and share, through visual and textual analyzes of carefully selected case studies, how successfully these cities have been designed, from the architectural point of view.

2. Introduction

2.1 Importance of the research

China's incredible economic development over the last few decades has led to mass urbanization, which is characterized by constant growth. The rural population inhabits large urban centers. However, this transformation causes a very expensive life. This naturally leads to the development of suburban areas. In order to activate suburban regions of large urban centers and to attract people there, Western-themed towns appeared. In other words, themed towns are replicas of other cities, their copies.

We can recognize architectural replications all over the world. Copying buildings or imitating a particular style of architecture is nothing new. But copying entire cities, that's unique, that's new, and therefore it is important to be researched.

2.2 Need and purpose of the research

It is necessary to point out that these projects are not only replicas of Western cities, but they are usually inauthentic replicas. These towns have no history. All of their visual value fits into their facades, which are there to provide an international atmosphere and an image of wealth.

These Western-themed projects are also receiving a lot of media attention. Various media sources from around the world have given them so much free advertising and exposure, and consequently, they have become known to the general public. Thus, this developed their tourism potential, and at the same time opened the door for many discussions.

Besides all of the mentioned features, these towns are Chinese towns, even if they are inspired by Western styles. These are places where families live, where children grow up, where they spend their free time, where they learn, etc. Therefore, the most crucial part for the life of citizens is the structure of each town, not its appearance. From there, with the purpose to find, to differentiate, to bring together, to overview, various analyses of these structures are the need of this research.

2.3. A brief preview of the research

This research is divided into two major parts. The first major part is a review of the literature, which is based on published works related to the chosen topic. The focus of this section is on seeking answers to carefully selected questions, in order to fully present and understand the topic.

The second major part is case studies, which deal with various analyzes of carefully selected examples, in order to extract the main characteristics of their structures. These case studies have focused on general site analysis, natural conditions and potentials, historical analysis, land use analysis, building structure analysis and transportation analysis.

3. Literature Review

The first aim of this literature review was to build my knowledge and advance my understanding of this topic. The second and main aim of this literature review is to demonstrate this knowledge and update all readers about this subject. This literature review is based on information from published books and research papers, and the literature is selected on its relevance to answer the following questions:

1. Why kitsch is the foundation of forgeries nowadays?
2. How do we define ‘forgery’?
3. What was the purpose of copies and forgeries throughout history?
4. What are the characteristics of the culture of ‘copying’ in China?
5. What can we learn from the 'Western Themed Cities' projects in China?

3.1. Why kitsch is the foundation of forgeries nowadays?

When we mention the word 'forgery', it is very easy to find synonyms such as fake, replica, mimicry, copycat... Nowadays, these terms are seen as side effects of the kitsch. Therefore, first, we must clarify the idea of kitsch, and why forgery is identified as its result.

According to Kulka (2002), we use the term kitsch very often, and we presume that its meaning is reasonably clear, but when we want to define kitsch, we can see that it is not an easy task and that many authors who have tried to analyze its concept have soon noted its extraordinary complexity and elusiveness. Although it is difficult to make a short and clear definition of kitsch, a strong link between copying and counterfeiting with kitsch is created during the beginning of the mass production of art goods. According to Emmer (1998) mass production evolved with members of the 'lower' classes, whos only purchase kitsch because it is an imitation of 'upper' class art forms, and they would like to have the appearance of belonging to that class. This is supported by the research of Binkley (2000) who detected three ways in which kitsch aestheticizes repetition, and the first one is an emulation of cultural products, which often copies the signs of class status.

Consequently, the art goods that were considered tasteful started to be copied. But that created a new side effect. Ward (1991) pointed out that copying of what what was regarded as tasteful creates objects of no value because they became common. In the book written by Dorfles & Machale (1969), this was explained as degradation of whole original values to the level of kitsch symbol, after which the piece that was intended to remain unique, is recognized not by its real requires, but for a sentimental or technical substitute of these values.

Therefore, we can conclude that today's forgeries are the product of the kitsch culture, that supports the mass reproduction of artworks, that cause decreasing of their real values and creating new values that make them being recognized as kitsch symbols.

3.2. How do we define 'forgery'?

Even when we easily recognize and understand terms such as forgery, fake or copy, it is not easy to set their short and clear definitions, because of their complexity and intertwining between themselves.

In an article written by Gaiger (2001), we can find the following definition: 'Forgery undermines the modern concept of art, ridiculing and deglorifying the notions of illimitability, uniqueness, and originality on which it is based.' (p. 339). According to Negrich (2011), there is a clear difference between a fake and a forgery, and he expressed it as the difference between mere copying and intentional deceit. Negrich easily explained it through an example: 'If artist B copies the work of artist A at the same time that artist A creates his work then the work of artist B could not be a forgery. However, if artist B copied the work two decades after the original work was created then the work could be a forgery. Even though artist B could have the exact same intentions for his work in each example, the above definition of forgeries treats the two cases differently' (p. 3).

3.3. What was the purpose of copies and forgeries throughout history?

'Until the nineteenth century, the copy of an original work had its own value, it was a legitimate practice. In our own time, the copy is illegitimate, inauthentic: it is no longer "art." Similarly, the concept of forgery has changed - or rather, it suddenly appears with the advent of modernity.' (Scott, 2016, p. 84).

According to Negrich (2011), forgers seem to existed during the second millennium before the current era, and they were the Phoenicians who trafficked in art forgeries and lived near the Mediterranean and the Adriatic sea. Negrich also mentioned that many artists for centuries openly copied works and styles of known artists, and this was often seen as a manifestation of respect and honor for the original artist.

Gaiger (2001) points out, in his article, that throughout the Classical period, the works of celebrated Greek artists served as prototypes for other artists, and the culture of 'copying' of Greek works was continuous with a long-standing tradition.

3.4. What are the characteristics of the culture of 'copying' in China?

Fong (1962) highlighted that forgery in China has never carried such dark connotations as it does in the West, and the legal or ethical problems never appeared since the aim of studying art has always been either aesthetic cultivation or pure enjoyment, so the ability to create a perfect forgery of masterpieces was a matter of virtuosity and pride. Fong also pointed out that copying in ancient China was not only an honorable but also a vitally necessary form of art because it was the only way to reproduce, circulate and perpetuate treasured masterpieces.

Lin (2011) pointed out that copying is an integral part of Chinese culture because traditional Chinese Confucian education required reciting and copying, therefore, it was essential for students to learn to copy.

3.5. What can we learn from the 'Western Themed Cities' projects in China?

'Situated in a vast ring around the city, the nine towns will eventually house a population of more than 500 000 people. Hand-picked foreign architects have designed the towns, each meant to evoke the urbanism of a different Western nation, including Italy, Spain, England, the United States, Sweden, the Netherlands, Australia, New Zealand, and Germany. Known as 'One City, Nine Towns', the project began as a pipe dream of former Shanghai Communist Parry Secretary Huang Ju, who conceived of the themed towns as a way to celebrate Shanghai's history as a global city' (Campanella, 2012, p.88). Large-scale projects like 'One City, Nine Towns' allow us to better understand the culture of copying in China's modern architecture, and the reasons behind it.

It is true that large projects based on replicas were also occurring in other areas but in a different context. Often, in certain cities, based on their traditional architecture, a trend of fake historic buildings appears as a way of promoting tourism or encouraging revitalization. This was researched by Levi (2005), who concluded that this kind of fake architecture is contextual, and it supports community aesthetics by increasing the historic character of a city.

According to Campanella (2012), these kind of projects in China are about selling a lifestyle, not just a home, and it is caused by extreme competition in the property market, where developers copying ideas and motives from elsewhere, in search of anything that will make their real estates attractive.

According to Hartog (2010) thematically parts can be seen as a reaction to the lack of identity from which many new cities suffer, but they also have a germinal function, stimulating larger-scale development. Hartog points out that the international influence in architecture and urbanism is hoped to attract the prosperous Chinese middle class, and even create a tourist value because due to poor air quality, more and more Chinese escape from the city during the weekend to visit historical towns and parks.

Lin (2011) points out that this copying practice in China nowadays is a result of the government's willingness to foster multiculturalism. But at the same time, and contradictory, we have an internet blockade in China, that is according to Roberts (2018), made from a desire to censor and suppress negative information, and it completely blocks multiculturalism.

Why do citizens support projects like this by buying the properties? There are two phenomena that may be the reason for that. The first phenomenon is explained by Knapp (2000), who mentioned that construction boom in China over past two decades has led to the destruction of countless humble as well as fine old dwellings, and this was also supported by their residents and others who regard them as too ordinary, outdated, and dysfunctional to maintain. The second phenomenon is a Western influence on Chinese values and it is explained by Capen (1913), who wrote that with the influence of western governments western lifestyle, values, knowledge, thoughts, and achievements have been spread in China, especially among students and the progressive classes. If we combine these two phenomena, we will have perfect buyers for real estates of Western replicas, who will enjoy Western brands and lifestyles.

According to Bosker (2013) China has billions of square feet dedicated to projects of themed towns, and these homes in subtle but important ways shaping the behavior of their occupants because they are designed as permanent habitat to hundreds of thousands of Chinese, who will raise children, wash cars, cook dinners, and live out their daily routines here, but in accordance with Western lifestyle, values, and rituals. Bosker points out that this replication program goes beyond architecture and construction techniques, and it recreates not only the superficial appearance of Western historical cities, but also the atmospheric and experiential local color of the originals through such devices as foreign names, signage, and lifestyle amenities. Bosker also points out that the foundations of these projects are Chinese technology, mechanical and infrastructural capability, financial resources, powerful government support and clients from a growing middle class, which includes a population of between 100 million and 250 million consumers. Bosker concluded that all off this give force to ingenuity and innovation, and it's just a part of the process of seeking a new identity in Chinese architecture.

According to Zhao (2018), in 2016, the Chinese government released a document that requires for all new buildings to be suitable, economic, green and pleasing to the eye, but despite all this, William Shakespeare's historic hometown was recreated as part of a new tourist town called San Weng, in Jiangxi province. Zhao also mentioned that at first, these cities had a small population, so they were named 'Ghost Towns', but now they are very populated, they function normally and even developing with the construction of subways, etc.

3.6. The conclusion from the literature review

After summarizing the entire literature from this review, we can conclude that forgeries in China are often seen as the manifestation of respect and honor for the original work and as technological, mechanical and infrastructural capability of the country. We can also conclude that ideas behind creating Western-themed towns are seen as the

spread of multiculturalism, as the creation of a global character in cities, as the provider of new lifestyles, and this phenomenon is seen as part of the process of seeking and creating a new identity in Chinese architecture.

4. Case Studies: Aim & Methods

The main aim of these case studies is to do analyzes and then, in relation to the results of these analyses, to make comparisons, conclusions, and arguments related to the selected topic. We are in a time when we are striving for sustainable, creative, smart cities, with a focus on social efficiency, education, innovation, communication, technology, etc. Therefore, for the case studies, I chose Sky City and Thames Town, as these are themed towns created in the recent past, and adequately present and describe the phenomenon of Western-themed cities in China. Through various analyses, I want to show the development of these themed towns and draw conclusions about their structure, characteristics, and impacts from an architectural point of view.

I used several working methods for this research. I mostly relied on visual analysis, which I supplemented with textual analysis and historical analysis. Therefore, I was able to write my observations and draw some conclusions and finally enrich them with the help of textual data.

5. Case Study: Sky City

5.1. General Site Analysis

Sky City is located in the suburban area of Hangzhou, about 18 kilometers from the center of the capital of Zhejiang Province, China. The city began to develop around 2007, with the construction of a Western French-themed town. Since then, this is the center of development of the area, with a current population of about 40 000 people, dominated by Han people. The political authority, plan, and project of Hangzhou conditioned the economic development of this suburban area today. In 2019, Sky City received the provincial 'Urban Leader Award', for its strong strength in real estate development, outstanding contribution to the Hangzhou property market, and social development.

Table 1: General information about Sky City

General Info	Value
Chinese name:	Tiāndūchéng (天都城)
Foreign name:	Tiandu city / Sky City
Country:	China
Province:	Zhejiang (浙江)
City:	Hangzhou (杭州)
District:	Yuhang (余杭)
Address:	Xingqiao Street (星桥街道)
Development:	Since 2007.
Development cycle:	20 years
Town's area:	7600 acres (about 31km^2)
Construction area:	4.8 million m^2
Total investment:	10 billion 元 (about 1.28 billion €)
Planned population:	80 000 to 100 000 citizens
Current population:	40 000 citizens
Distance from the city center:	18 km

5.2. Natural conditions and potentials

The location is characterized by low terrain, dense river networks and dense lakes, rich in products, and has the typical characteristics of a ‘south of Yangtze river‘ area.

Sky City is located in the subtropical monsoon region and belongs to the subtropical monsoon climate, with four distinct seasons and abundant rainfall. The annual average temperature is 17.8 ° C, the average relative humidity is 70.3%, the annual rainfall is 1454 mm, and the annual sunshine hours are about 1765 hours. Summers are hot and humid. In contrast, winters are cold and dry. The spring and autumn climate is pleasant, and it is the golden season for sightseeing.

The area of Hangzhou is rich in products and it is known as the 'Home of fish and rice'. The agricultural production conditions are unique, with a wide variety of crops, forest trees, livestock and poultry, and more than 260 varieties of forest fruits, tea mulberries, and flowers.

5.3. Historical Analysis

Sky City is a new city, little more than a decade old, purposefully planned and designed for suburban development, and therefore it is very limited in the terms of historical analysis.

There are no records and events in recent history that had implications for the spatial development of the selected area. The urban and architectural evolution of location followed a pre-planned development that was conditioned by settling a newly created city (Figure 1 & Figure 2). There is not cultural and historical heritage or protected area of the site that can impact future designs or development. The existing context of buildings in the city is a mix of thematic Western styles and the contemporary style of Chinese social housing architecture, with a lack of traditional building experience.

Figure 1: Aerial views of the location from 2003.

Figure 2: Aerial views of the location from 2019.

5.4. Analysis of land use structure

The purpose of this analysis is to discover the real land uses that exist or predominate within the selected area of investigation and the interrelation of different land uses. Available material and data from the Baidu Maps platform were used for the analysis.

The results of the analysis are presented graphically in the following attachment (Figure 5), and according to them the dominant spatial unit, ie. the dominant use of the land is residential, while the educational use of land is to a lesser extent. Other land uses, like a commercial, health care, etc. exist in the near or far area, but not within the boundaries of analysis. In developed areas, we can recognize public open spaces, semi-public open spaces and private open spaces.

Within the selected location there are areas that are not yet developed or are under development. The current developing area is also planned as a residential zone.

5.5. Analysis of building structures

The purpose of this analysis is to discover building structures and provide information on the function that exists or predominate within the selected area of investigation. In the selected location we can distinguish four zones in which there are different groups of objects, with a dominant residential purpose. Zones are shown graphically in the following attachment (Figure 5). The available material and data from the Baidu Maps platform were used for the analysis.

Figure 3: Sky City (left half) and Paris (right half)

Figure 4: Sky City (left half) and Paris (right half)

Zone 1 is characterized by buildings that are thematically inspired by the Wester French architecture and motifs of Paris (Figure 3 & Figure 4). The number of stories is low, usually less than 8 floors. The main purpose of the buildings is residential and can be described as a large multi-family (apartments/flats) zone. Ground floor uses may be for commercial purposes. Buildings are characterized by spaces with a closed or open character and spaces formed by geometrical edges. In this zone, we can identify good relationships of form and mass, scale and proportion, rhythm and repetition, and geometry and hierarchy. On buildings, we can recognize stylistic elements and a lot of facade ornaments and decorations. This is the first built zone and it served as a prerequisite for the development of this area. Zone one is also characterized by French style streets. The whole building complex with art shops, various forms of street performances, sculptures, paintings, etc., provide a charming scenery of a French rural town.

Zone 2 is characterized by buildings that are thematically inspired by Western American architecture. The number of stories is low, usually less than 7 floors. The main purpose of the buildings is residential and can be described as single-family / multi-family attached (mansions) zone. Buildings are characterized by private spaces with closed character. In this zone, we can identify good relationships of private space, structure, and proportion.

Zone 3 and Zone 4 are characterized by buildings that are built according to modern Chinese social housing architecture. The number of stories in zone 3 is usually less than 7 floors. The number of stories in zone 4 is usually higher than 12 floors. The main purpose of the buildings in zone 3 and zone 4 is residential and can be described as a large multi-family (apartments/flats) zone. In zone 4 we have buildings that are under development. All buildings in all zones were built after 2007, and therefore this is a newly built area.

5.6. Analysis of the transport structures

Roads as public spaces and traffic structures are crucial for space perception. Therefore the purpose of this analysis is to discover existing transport facilities within the selected area of investigation and its connection and integration into the transport networks. Available material and data from the Baidu Maps platform were used for the analysis. According to the analysis at the selected location, there are streets with different proportions, clear divisions of driving lanes and side areas, different types, shapes and sizes of road spaces, appropriate traffic furniture, materials, and lighting equipment (Figure 5). Therefore, traffic in the selected location is characterized by satisfactory capacity and user-friendliness. The type of transport is passenger, while purpose and distances can be described as internal transport.

Traffic is characterized by very good circulation, within and around the site, good access, and good accessibility for persons with disabilities. We can identify multiple types of used transportation at the selected location, and therefore we can recognize motorized traffic, local public transport, cycle traffic, foot traffic and dormant traffic (parking spaces). All of them create a hierarchical network, so the traffic is evenly distributed. Construction of Metro Line 3, which connects Sky City to Hangzhou, started in early 2018, and it is still under development.

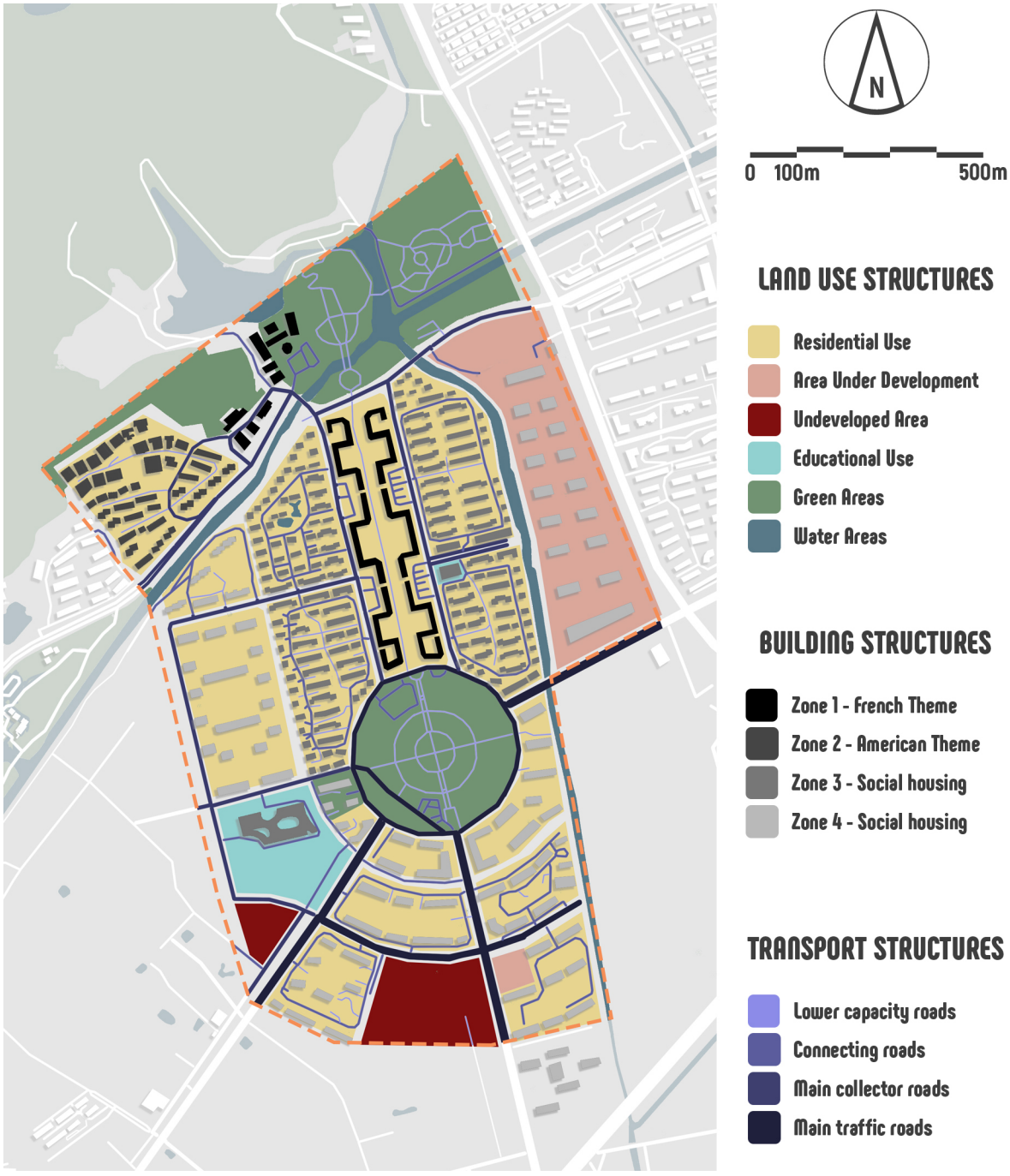

Figure 5: Graphical presentation of the structural analysis of Sky City

6. Case Study: Thames Town

6.1. General Site Analysis

Thames Town is located in the Songjiang District, in the core area of Songjiang New Town, about 30 kilometers from the center of Shanghai in China. The city began to develop in 2001 and it had three phases. During 2001-

2003 the city was designed by the architectural firm 'Atkins Design Studio', with a British theme for 10 000 inhabitants. During 2003-2004 the infrastructure and main facilities were built and in the period 2004-2006, all residential buildings were built. In 2004, Thames Town won the title of Shanghai's 2004 Most Investment Potential Real Estate.

The overall layout of Thames Town, from brick to tile, reflects the original European British town style. The city is named after the river Thames from London. The town consists mostly of single-family housing, such as single villas and multi-story apartments, with few commercial or community facilities. It also consists of continuous multifunctional pedestrian streets and a lakeside British style square. Some of the architecture was directly copied from buildings found in England, including the main square church, pubs, and shops.

All the houses sold very quickly. However, the clientele was relatively wealthy, so the homes were bought as investments or other homes, so the number of citizens was low. That is why in the beginning the Thames Town was nicknamed as 'Ghost town'.

Thames town took full advantage of the good ecological environment of the Shenjing pond, and now with a green coverage rate of 60%, it is a large community with multiple functions such as living, tourism, and leisure. Like every other Western Themed Town in China, it has become very popular as a wedding photography location, because it provides foreign backgrounds.

If we look at the microsite of Thames Town, it is located between the residential area and the business area of Songjiang New Town. In the immediate location of Thames Town, there are ‘Shanghai Harmony Kindergarten’, ‘Songjiang Primary School’, ‘Sanxin Primary School’, ‘Songjiang University Town’, shopping malls, hospitals, post offices, banks, ‘Sixian Park’, ‘Central Park’. Near the selected location there are no hazards and facilities that produce a certain level of pollution, noise, smoke, odors, etc.

Table 2: General information about Thames Town

General Info	Value
Chinese name:	Tàiwùshìxiǎozhèn (泰晤士小镇)
Foreign name:	Thames Town
Country:	China
Municipality:	Shanghai (上海)
District:	Songjiang (松江)
Development:	2001-2006
Client / Developer	Shanghai Hengmao Real Estate Co.
Designer	Atkins Design Studio
Town's area:	1km^2
Construction area:	500 000 m^2
Green coverage rate:	60%
Total investment:	5 billion 元 (about 640 million €)
Planned population (by 2020):	10 000 citizens
Distance from the city center:	41 km

6.2. Natural conditions and potentials

The location is characterized by low terrain and its territory belongs to the Yangtze River Delta Plain. There are also low mountain hills zones in some surrounding areas.

The proximity of the small lake Shenjing provides natural views, and sensory qualities and variations of light, sound, and smell. The surrounding area is characterized by the dense river and lake networks.

Thames Town belongs to the northern subtropical monsoon region and its climate is affected by alternating warm and cold air. The climate is warm and humid, with four distinct seasons, abundant rain, sufficient sunshine, and long frost-free period. The annual average temperature is 15.4 °C. The annual average precipitation is 1103.2 mm and there are on average 137 rainy days. The rainy season is from June to July, with an average of about 20 days. Autumns and winters are foggy.

The natural environment of the area of Songjiang is characterized by medicinal plants, different types of bamboo, fruit trees, and herbal flowers.

6.3. Historical Analysis

Songjiang District has a longer and richer history than the old city of Shanghai and has been a major trading hub in the Yangtze Delta region for centuries. However, Songjiang New City is part of a new wave of development aimed at diverting the population from central Shanghai and activating suburban areas (Figure 6 & Figure 7). Within that wave of development, the 'One City, Nine Towns' project was born, which aimed to create nine new West-themed towns, in the suburban area of Shanghai. Thus, Thames Town was born in Songjiang New City as a result of an international competition won by British architectural firm Atkins. Therefore, Thames Town is generally a fresh project, so it is very limited in historical analysis.

Thames Town was envisioned as an attractive suburban residential environment for professors affiliated with the than freshly-built Songjiang University Town that had the capacity of a total of 150 000 students. In addition to providing accommodation, Thames Town is also conceived as a tourist resource. Therefore, Thames Town can be seen as a fully marketable project, with the idea of reaching Western quality and lifestyle standards.

Thames Town has come a long way since being seen as a failure in the industry. The reason for this was that it was too far from Shanghai during the construction period. However, with the developed economy and transportation, things have changed dramatically. As the population in Songjiang New City increased, the occupancy of Thames Town increased too. This has also transformed Thames Town into an urban tourism destination.

There are no records and events in recent history that would affect the spatial development of the selected area. The urban and architectural evolution of the site followed a pre-planned project and plan, with a clearly defined goal. There is no cultural and historical heritage or protected area of the site that may affect future design or development. The existing context of city buildings is in line with the British theme.

Figure 6: Aerial views of the location from 2008.

Figure 7: Aerial views of the location from 2019.

6.4. Analysis of land use structure

The purpose of this analysis is to discover the real land uses that exist or predominate within the selected area of investigation and the interrelation of different land uses. Available material and data from the Baidu Maps platform were used for the analysis.

The results of the analysis are presented graphically in the following attachment (Figure 10), and according to them the dominant spatial unit, ie. the dominant use of the land is residential, with different building types such as individual houses, terraced houses, and multi-story buildings. At the site, we can also find other land uses, like educational zone, commercial zone, health care zone, public green space, tourist zone, etc. Also, all other land uses can be found in the immediate vicinity of the analyzed location.

At the selected location we can recognize open public spaces (public square, public green space, lakeside area...), public open spaces associated with certain facilities (educational zone), semi-public open spaces (the inner courtyards of apartment complexes), private open spaces (gardens). Open public spaces provide natural spatial experience and qualities. They have recreational and functional value. The interaction of open space and housing structure is defined by proportional surface area and spatial distribution.

6.5. Analysis of building structures

The purpose of this analysis is to discover building structures and provide information on the function that exists or predominate within the selected area of investigation. The available material and data from the Baidu Maps platform were used for the analysis. Zones are shown graphically in the following attachment (Figure 10).

The city of Thames is modeled after a traditional rural British village. All buildings have different heights and there is no repetition in terms of design. According to local building regulations, all buildings have a concrete frame and are finished with decorative brick and tile leather. All other materials and furniture were imported from Britain. In the selected location we can distinguish four zones in which there are different groups of objects, with a dominant residential purpose.

The entire town has a total construction area of 500 000 square meters. From the perspective of volume distribution, Thames Town has closed residential areas, open residential buildings, open commercial and residential areas, commercial blocks, office buildings, schools, hotels, health centers, fitness clubs, etc. It is planned that all buildings meet the criteria in terms of form, structure, scale and proportion, rhythm and repetition, hierarchy, public space and private space.

Zone 1 is characterized by single-family detached individual housing. The main purpose of the buildings is residential. The predominant types of buildings are villas.

Zone 2 is characterized by buildings of a few floors. The main purpose of the buildings is residential (Figure 8 & Figure 9). The predominant types of buildings are low-rise apartments.

Zone 3 is characterized by buildings with mixed commercial and residential purpose and different ground floor uses. This zone contains buildings of three to six floors. The first (ground) floor is usually a business area, and other floors are housing. The main business formats are lively and long-term business types, such as catering, bars, the wedding industry, and galleries.

Zone 4 consists of buildings that are not intended for residential use, but those buildings that are classified as an educational, commercial, commercial, tourist, etc. These buildings vary in shape, height, mass... It is important to point out a replica of Bristol Cathedral which is located at the open public square.

Figure 8: View from Zone 2 towards Public Square

Figure 9: Different British-themed facades in Zone 2

6.6. Analysis of the transport structures

The purpose of this analysis is to discover existing transport facilities and characteristics within the selected area of investigation and its connection and integration into the transport networks. Available material and data from the Baidu Maps platform were used for the analysis.

According to the analysis at the selected location, there are streets with different proportions, types, shapes and sizes of road spaces, satisfactory capacity, appropriate traffic furniture, materials, and lighting equipment (Figure 10). The transport system meets all needs in terms of circulation, access to location and accessibility within a location. Different street patterns and different types of streets are recognized, ranging in width from 4.5 meters to 25 meters. This is shown graphically in the following attachment (Figure 6).

Thames Town is an organically grown town, and its concept was to create a sense of community through its hierarchy of open spaces with streets and squares. Therefore the main transportation feature of Thames Town, and what immediately catches your attention, is the transportation system produced by a continuous multifunctional pedestrian street and a lakeside British-style square. This type of transportation network allows and creates a good place for residents and tourists to meet, perform, relax, and socialize.

The streets, which are often no more than 6 meters to 10 meters wide, are pedestrianized. These are moderate to low-use roads. With an aim to free the town's center, several underground car parking areas have been constructed, and they represent dormant traffic. These areas also serve as emergency shelters. There are no transport areas that are particularly inconvenient or dangerous.

It is important to point out that the establishment of several rail transit stations, such as Songjiang New Town rail station and University Town rail station, has greatly changed the situation of Thame Town and increased its occupancy rate.

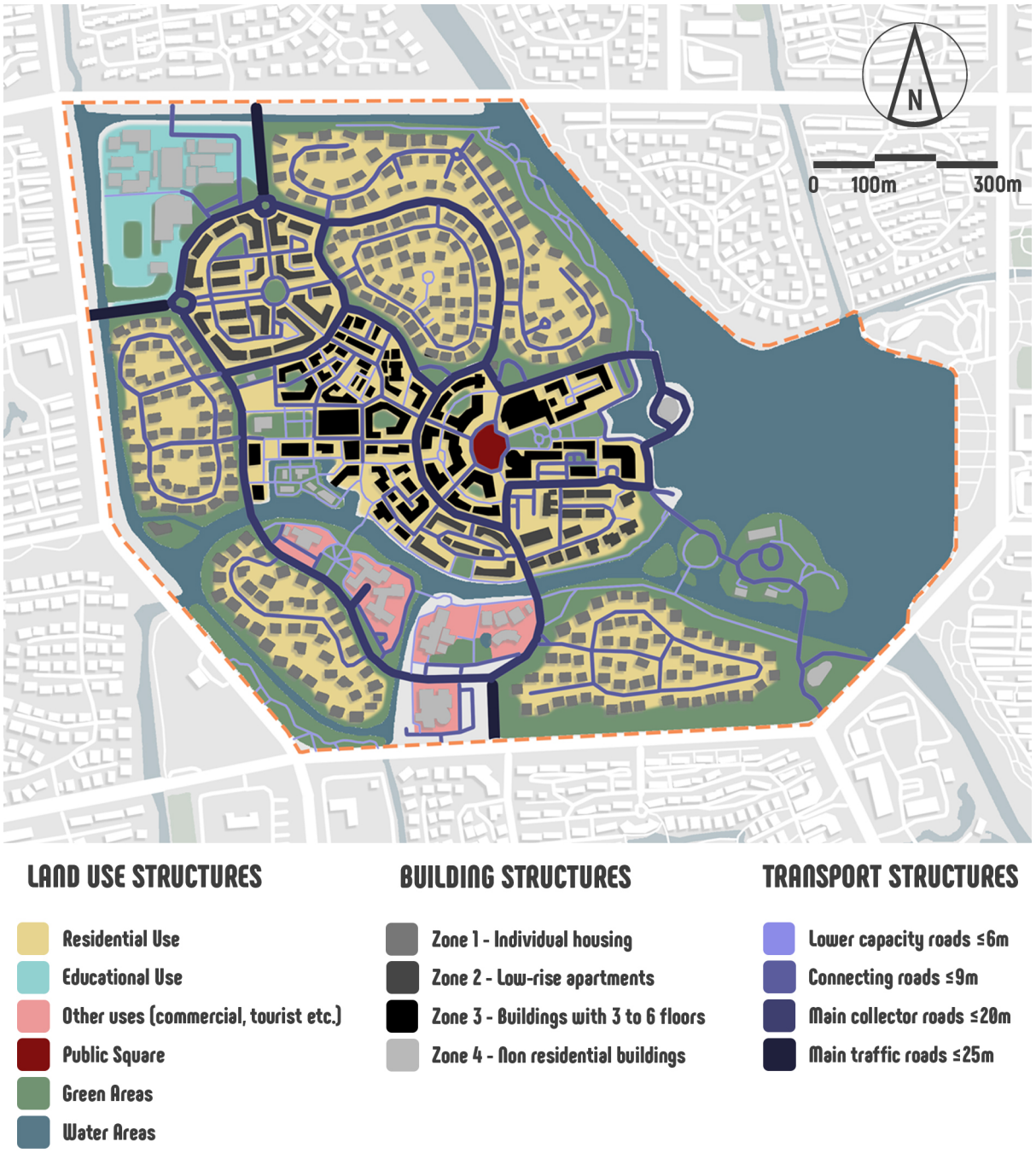

Figure 10: Graphical presentation of the structural analysis of Thames Town

7. Conclusion

After summarizing the entire literature from this review and after summarizing the results of analyses of selected case studies, we can conclude that all main goals of this research work have been successfully fulfilled.
We can conclude that forgeries in China can be seen as the manifestation of respect and honor for original works and, as a part of the process of seeking and creating a new identity in Chinese architecture, they serve to create a multicultural character in the city.

According to the research of case studies, we can conclude that Western-themed cities are being built in different parts of China characterized by different natural conditions. They are mainly built in suburban areas, with the aim of attracting citizens with their international appearance, thus enabling further development of the area. The

dominant land use in these towns is residential, while all other required land uses (educational, commercial, health care...) are located within or around the site.

Due to the small population immediately after construction, each town was nicknamed as 'Ghost Town'. However, with the construction of metros and the improvement of transport infrastructure, the accessibility of the towns became better, thus the population sharply increased and enabled further, previously planned, development.

Considering that all these towns are made with the aim of creating and presenting Western identities, characteristics, and atmosphere through architecture, we can come across many different building structures, which primarily differ in chosen Western appearance, and then in dimensions, materials, etc.

And finally, as these cities provide international backgrounds, they have caused the rapid growth of the wedding industry in these locations, much more than other businesses. Also, these cities have great tourism potential.

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Synthesis of Chalcones from Acetone and tetrazole and 2-acetyl naphthalene Assisted by Microwave

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Abstract
In the present study, we understood the total synthesis one chalcone derivative via Claisen-Schmidt condensation of the respective aldehydes and ketones using Microwave assisted irradiation method. In the microwave environment, chemical reactions usually proceed faster and give higher yields with fewer by- products. In the synthesis, a common aldehyde namely tetrazolo {1, 5-a} quinoline-4-carbaldehyde was used while the ketones used were respectively acetone, 2- acetyl Naphthalene. The Chalcone synthesised from Tetrazolo {1, 5-a} quinolone-4-carbaldehyde and acetone was 4-(tetrazolo {1, 5-a} quinoline-4-yl) but -3-en-2-one. The Chalcone synthesised from Tetrazolo {1, 5-a} quinoline-4-carbaldehyde and 2-acetyl Naphthalene was 2E-1-(naphthalene-2-yl)-3-(tetrazolo {1, 5-a} quinolone-4-yl) prop-2-en-1- one. The starting aldehyde was Tetrazolo {1, 5-a} quinoline-4-carbaldehyde necessary for the Claisen-Schmidt condensation was in turn synthesized from Acetanilide which and Vilsmeier reagent (DMF and $PoCl_3$) to produce the intermediate compound 2-chloroquinoline-3-carbaldehyde. This intermediate 2-chloroquinoline-3-carbaldehyde was then treated with sodium azide and acetic acid with ethanol as solvent to produce Tetrazolo {1, 5-a} quinoline-4-carbaldehyde. Structure of the compound were confirmed by spectral data such as IR and ^{1}H-NMR.

Keywords: Tetrazolo, Quinoline, Acetone, Condensation, Microwave Irradiation And Chalcone

Introduction

Organic synthesis is one of a special branch in chemical synthesis and is concerned with construction of organic compounds by reactions. It is believed to be one of the most vital in organic chemistry because the organic molecules contain higher level of complexity compared to pure inorganic compounds. Organic synthesis specifically becomes centre of attraction for many scientists because of the ability to produce beneficial products artificially for human welfare. Organic synthesis has played a very important role in many sectors such as pharmaceuticals, agriculture and others.

On the other hand, development in chemical instruments becomes one of the factors for many researchers to carry their researches more effectively. Advanced technology is able to produce instruments such as NMR, HPLC and others with higher accuracy, higher quality and in less time. The inventions of such scientific instruments promote the organic synthesis sector to widen up the study of interest.

Flavonoids with 1, 3-diarylpropane skeleton can be classified as an outstanding class of naturally occurring compounds (Avila et al., 2008). Chalcones or 1,3-diphenyl-2-propen-1-one derivatives are open chain unsaturated carbonyl system in which two aromatic rings are joined by three carbons having α, β- unsaturated system (Avila

et al., 2008). Chalcones can be considered as the precursors of flavonoids and isoflavanoids (Tomar et al., 2007) and are secondary metabolites of terrestrial plants that exhibit various biological activities (Narender and Reddy, 2007)

Objective of the study

The objective of the study are:

i. To synthesise Chalcone derivate
ii. To characterize the synthesized Chalcnoe derivative
iii. To demonstrate the importance of microwave assisted synthesis

Methods

Thin layer chromatography (TLC) was conducted using thin layer aluminium plate Merck pre-coated silica gel F254 of 0.2 mm in thickness. The spots were viewed under ultraviolet (UV) light, followed by spraying the plate with iodine. Column chromatography (CC) was performed on silica gel Merck 70-230 mesh.

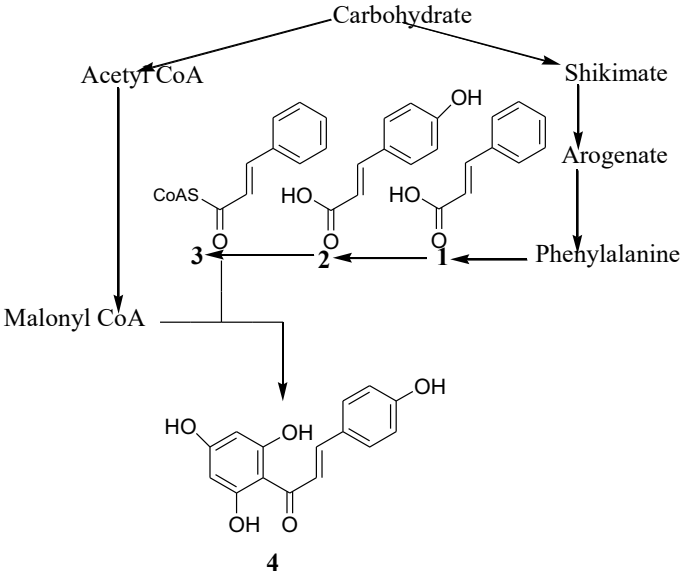
Solvents were purified according to the procedure given in Vogel's Text Book of Practical Organic Chemistry, 5th edition, London. Petroleum ether of boiling 60-80 0C. Several instruments were used characterize the compound in the experiment. Infrared (IR) spectra were recorded on a KBr pellet. ^{1}H-NMR was recorded by at 300 MHz and 400 MHz on Varian Gemini Unity Spectrometer using TMS as internal standard.

Microwave assisted synthesis was carried out by using multifunctional microwave system and modified LG microwave oven. The melting points reported were determined in Polmon make instrument.

The starting materials used in this study were commercially available ketones such as acetone, 2-acetyl Naphthalene. Other starting materials was Tetrazole aldehyde which was synthesized in the laboratory from Acetanilide. Other chemicals were acetic acid (CH_3COOH), sodium hydroxide (NaOH), sodium azide (NaN_3), DMF, $PoCl_3$, conc HCl. The organic solvents used were acetone, petroleum ether (PE), absolute ethanol (EtOH), methanol (MeOH), ethyl acetate (EtOAc), hexane, chloroform ($CHCl_3$).

Biosynthesis of Chalcones

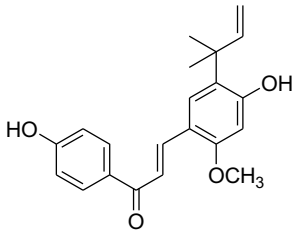
All chalcones derive their carbon skeleton from two basic compounds, malonyl CoA that synthesized from the glycolysis intermediate acetyl-CoA and carbon dioxide, and the CoA ester of hydrocinnamic acid. The aromatic ring B and its adjacent 3-carbon side chain are derived from L-phenylalanine via the Shikimate pathway leading to the formation of the C15 chalcone intermediate. Flavonoids and other compounds associated with flavonoids are derived from this chalcone intermediate by stereospecific action, oxidative rearrangement and other methods. Scheme 1 shows the biosynthesis of chalcone in which the next process after chalcone will lead to the production of flavonoids and its derivative. Cinnamate (1), 4-coumarate (2) and 4-coumaroyl-CoA (3) are involved during the synthesis of natural chalcone (4) (Jenson, 1965).



Scheme 1 : The Biosynthetic pathway of chalcones

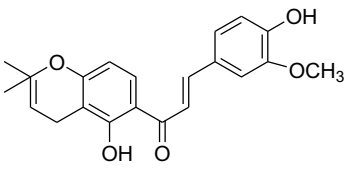
Naturally occurring chalcone

Naturally occurring chalcone have been reported to have multiple biological and pharmacological activities. The biological activity is mainly depends on the substitution group of chalcones. Licochalcone A (5) is a naturally occurring chalcone isolated from the roots of Glycyrrhiza inflate (licorice) which was proved to have in vitro and in vivo antimalarial and antileshmanial activities.



(5)

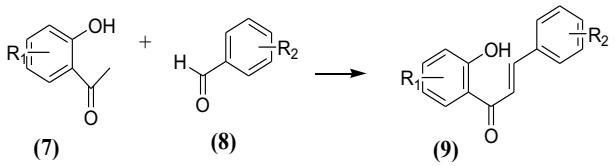
On the other hand 3-methoxy-4-hydroxylonchocarpin (6) isolated from the roots of Lonchocarpus utilis inhibits NADH ubiquinone oxidoreductease7n activity (Avila et al., 2008).



(6)

Claisen-Schmidt reaction

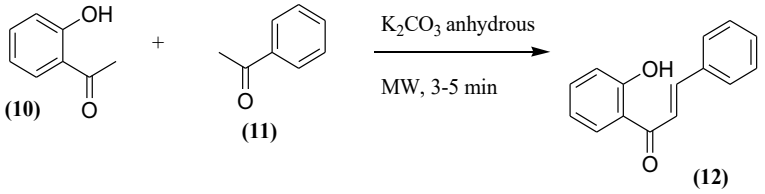
The claisen-schmidt condensation between acetophenone and benzaldehyde derivatives in an important C-C bond forming reaction which allows α, β- unsaturated ketone such as chalcones to be obtained (Climent et al, 2004). It is the most frequently used means of establishing the C6-C3-C6 flavanoid nucleus owing to the availability of starting materials such as 2- hydroxyacetophenone (7) and a C6-C1 unit, of benzaldehyde derivatives (8) to obtain a 2-hydroxychalcone (9). Compound (9) bearing A-ring substituent provided by the acetophenone (indicated as R1) and B-ring substituent provided by benzaldehyde (indicated as R2). The classical Claisen-Schmidt reaction is routinely carried out using aqueous sodium or potassium hydroxide or ethanolic sodium at 50^0C over a period of several hours. The benzaldehyde derivative is often used in slightly more than equivalent amounts.



Scheme 2 : The Claisen-Schmidt Reaction

Synthesis of Chalcones under Microwave Irradiation

The combination of supported reagents and microwave irradiation can be used to carry out a wide range of reactions in short times and with high conversions and selectivity, without the need of solvents. This approach proved beneficial since it offers several advantages over conventional heating techniques and accelerates the organic reactions (Varma, 1999). The air derived paste of 2-hydroxyacetophenone (10), benzaldehyde (11) and anhydrous K_2CO_3 was subjected to microwave irradiation for 3-5 minutes to produce 2-hydroxychalcones (12). This reaction gave a cleaner product with a high yield (80-90%) (Srivastava, 2008).

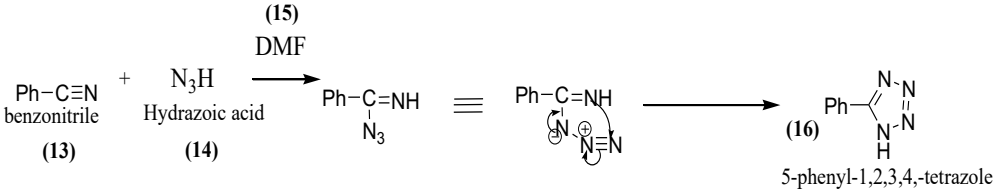


Scheme 3: Chalcone synthesis via microwave irradiation

Synthesis of Tetrazoles

There are various ways of synthesizing Tetrazoles. Some of the methods of the synthesis are described below.
By the addition of azide ions to nitriles

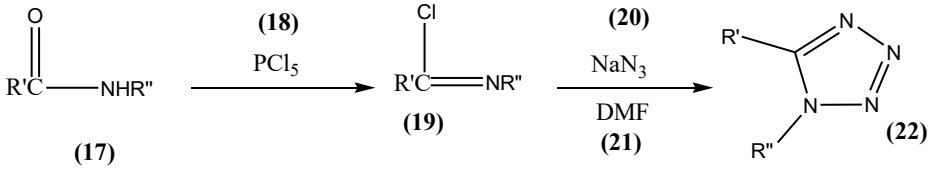
Addition of hydrazoic acid to compounds containing C-N multiple bonds give Tetrazole derivative.
For example: the reaction of benzonitrile (13) with hydrazoic acid (14) in DMF (15) gives 5-phenyl tetrazole (16)



Scheme 4: Reaction of benzonitrile and Hydrazoic acid

From amides.

Reaction of amides with PCl_5 (18) and sodium azide (20) in DMF (21) gives 1,5-disubstituted tetrazole (22)

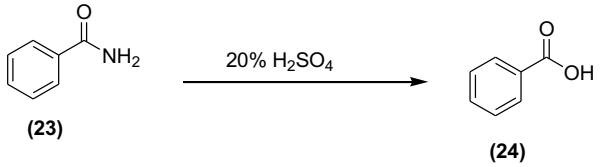


1,5 disubstituted-1,2,3,4-tetrazole

Scheme 5: Reaction of amide and sodium azide to give tetrazole

Past works on the Microwave assisted synthesis

In 1986 Richard Gedye and co-workers published a short communication in Tetrahedron Letters, entitled "The Use of Microwave ovens for Rapid Organic Synthesis" which for the first time described the utilization and advantages of microwave irradiation for organic synthesis. In this original publication four different types of reactions were studied, including the hydrolysis of benzamide to benzoic acid under acidic conditions (Scheme 6). Considerable rate increases (5-1000 fold) were observed for all investigated transformations when compared to classical thermal reflux conditions. The same year, an independent study by the groups Giguere and Majetich describing similar rate-enhancements in microwave-promoted Diels-Alder, Claisen, and even reactions was published in the same journal.



Conventional heating: 1hr, 90% yield
Microwave heating: 10min, 99% yield

Scheme 6: Synthesis of benzoic acid

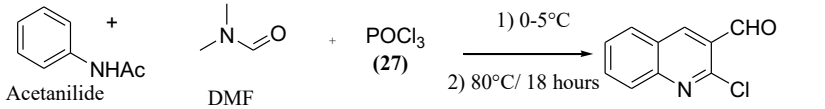
Results and conclusions

The biological activities that are being discovered in huge number of Tetrazole derivatives prompted us to the Tetrazole aldehyde () as one of the starting material for the synthesis of Chalcones. The chances for the synthesized Chalcones in this way to show biological activity would be higher. The Tetrazole aldehyde (28) was in turn synthesized using a commercially available compound Acetanilide (25) via chloroquinoline aldehyde as an intermediate.

The total scheme of the experimental work up is as follows:

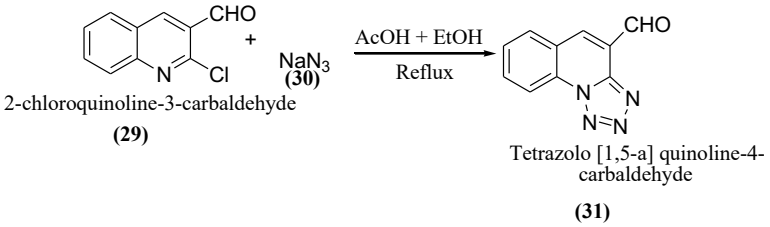
At first, the reaction of substituted amide (DMF) **(26)** with phosphorus oxychloride **(27)** is done which gives a substituted chloroiminium ion **,** also called the Vilsmeier Reagent. The initial product is an iminium ion, which then after cyclizes to give the final product of Quinoline carbaldehyde viz. 2-chloro quinoline 3-carbaldehyde **(28).**

Step 1: Synthesis of 2-chloroquinoline-3-carbaldehyde



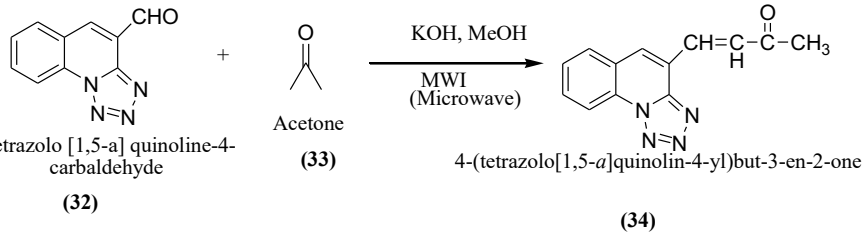
Refluxing the mixture of Quinoline carbaldehyde **(29)** and sodium azide **(30)** in ethanol yields the product Tetrazolo [1,5-a] quinoline-4-carbaldehyde **(31)** which is one the starting material for the synthesis of the chalcones

Step 2: Synthesis of Tetrazole Aldehyde



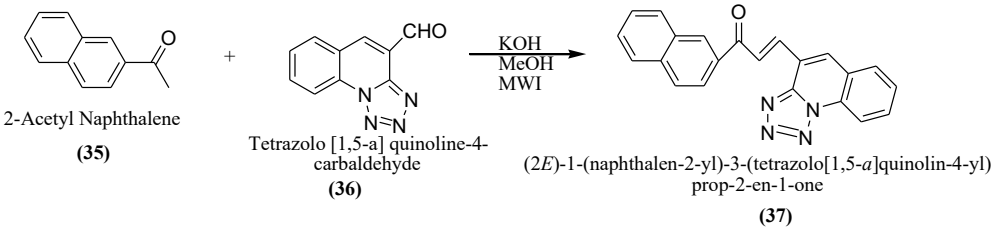
A mixture of KOH, acetone **(33)** and Tetrazole aldehyde **(32)** was kept in a 200 ml beaker and irradiated in a Microwave oven at 180°C for about 10min with the interval time of 30sec. To determine whether the complete reaction took place or not, the reaction mixture was analyzed with the help of Thin Layer Chromatography (TLC) on every 2min of the irradiation.

Step 3: Synthesis of a chalcone from acetone and tetrazole



A mixture of KOH, 2-Acetyl Naphthalene **(35)** and Tetrazole aldehyde **(36)** was kept in a 200 ml beaker and irradiated in a Microwave oven at 180°C for about 10min with the interval time of 30sec. To determine whether the complete reaction took place or not, the reaction mixture was analyzed with the help of Thin Layer Chromatography (TLC) on every 2min of the irradiation.

Step 4: Synthesis of chalcone from 2-Acetyl Naphthalene



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Local Wisdom in Reducing Greenhouse Effect on Balinese Traditional Settlement Patterns in Bongli Village, Bali, Indonesia

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Abstract
In general, housing and settlement development will have the effect of global warming, with different scale of effects. Warming occurs, not only because of the dominant built area but also due to the use of materials and equipment that can increase the comfort of the inhabitants. In Bongli Village, settlement patterns are arranged in such a way based on traditional procedures, by structuring the building period, as well as the shape of the building. Can traditional settlement and building arrangements reduce the greenhouse effect? The article discusses the patterns of settlements and buildings arranged in a traditional way related to the occurrence of the greenhouse effect such as the construction of housing and settlements at the present time. To achieve this, an understanding of the greenhouse effect from housing construction activities was carried out. To get data on traditional Balinese settlement patterns, field observations were made in Bongli Village to observe settlement patterns and the arrangement of buildings and their effects on global warming. Field observations will be narrated qualitatively in relation to the greenhouse effect. The results of field observations and discussions showed that Balinese Architecture and traditional housing and settlement patterns in the Village of Bongli, the building layout, as well as the building period used local materials, open spaces, so as to reduce energy use. Energy reduction due to functional buildings, so that during the day save electricity. Likewise, natural energy can reduce energy usage which means it can reduce the possibility of a greenhouse effect.

Keywords: Local Wisdom, Traditional Settlements Patterns, Greenhouse Effect

INTRODUCTION

Population growth both due to migration and naturally has changed the pattern of land use from extensive use to intensive use. In the past when the land was still sufficient there would be a spread of settlement patterns from existing ones to the surrounding lands (Shils 1971, Sukadana 1983, Ritzer 2007, 2008). This condition causes settlements to grow and develop around the location of existing settlements. However, the rapid population growth, especially in urban areas and the increasingly lack of land for housing and settlement development, the use of land tends to be intensified. Land use is tried as effectively and efficiently as possible so that settlements become jostled using existing space, especially spaces that can increase the comfort of housing. This condition has increased the tightness of settlement space. Crowded residential space has made the air less able to move freely, open space is limited, which reduces occupancy comfort (Dwijendra 2003, 2008, 2014).

To get the desired comfort then the use of electronic devices that can meet the expected level of comfort. Therefore, in a crowded environment the use of room conditioning will increase. This will require energy to operate. This persistence has continuously made the residential environment less comfortable and uses more energy. The use of room conditioning aids has used materials that can interfere with existing environmental conditions, such as preon gas. In addition, the use of electrically powered devices will produce exhaust gases and warm temperatures. Warm temperatures that come out (the result of the cooling process) will increase the temperature in residential neighborhoods where people live. This condition reduces the comfort of the dwelling inhabited (Suryanto 1983, Soemarwoto 1985, Sneyder 1985).

In addition, there is a tendency for the use of artificial or natural building materials in other communities to occur in other places (Wijaya 1986, Wikstrom 1995, Yogantari 2020). This condition will go through the process of its formation, its processing, and its transportation process. In this process will have an impact on the environment, especially on the formation of the greenhouse effect. Transportation will cause flue gas which can disturb the environment. Likewise, the processing of raw materials into finished materials will emit waste and energy that can accelerate the occurrence of the greenhouse effect.

Patterns of settlements in rural areas in Bali generally use traditional patterns handed down from generation to the next generation (Widiastuti 2017, Nurjani 2019, Dwijendra 2019, 2020). However, the tendency for changes in settlement patterns from traditional to modern settlement patterns is already apparent. The use of mass with each function (scattered) has been largely abandoned and replaced with buildings with compact functions. Likewise, the use of building materials which used to use building materials in the surrounding areas, has tended to change in a modern direction. Similarly, the space between buildings tends to be used optimally. The pattern of traditional settlements tends to shift from traditional conditions to modern directions with a practical economic tendency (Adhika 1996, Dwijendra 2010, Dharmayanty 2020).

Energy use in traditional settlement patterns tends to be less than energy use in modern settlement patterns. Traditional settlement patterns optimizing energy use have reduced energy use. On the other hand, modern patterns with a compact span with a wide span will require more energy than traditional. The use of electronic devices for the benefit of residential comfort requires a lot of power. The use of non-natural ingredients tends to cause micro temperatures to increase and increase overall temperature (Poedjawijatna 1983, Wikstrom 1995). Therefore, the use of modern patterns can affect the greenhouse effect conditions. In other words, changes in the use of settlement patterns have changed energy use and can affect environmental conditions.

This paper aims to analyze the traditional patterns of Balinese settlements in the village of Bongli in the use of energy for residential housing, the arrangement of settlement patterns, the regulation of building arrangements, the use of traditional building materials, as well as people's daily life patterns and energy use. This is done considering the tendency of changing settlement patterns from traditional settlements to modern settlements without or little understanding of the underlying. Change is caused by changing times and the effects of globalization and is afraid of being seen as not modern. The ease of information flow, the financial movement, the movement of people, the sophistication of the media, the rapid development of technology called the flow of globalization have changed the outlook of society towards the present. This has an effect on the pattern of settlements, building arrangements and patterns of use of building materials, as well as the daily patterns of life of the people.

RESEARCH METHODS

To achieve the purpose of study, field observations were made to Bongli Village, which is part of Sangketan Village, Penebel District, Tabanan Regency, Bali, Indonesia (BPS Tabanan 2019). Observations were made using a regional approach in a professional judgment conducted by researchers to describe the existing settlement patterns. In addition to conducting field observations also conducted with key informants who are local community leaders in order to complete the field observation results. In order to obtain information about the use of building patterns/building layout, field observations are carried out and compared with previous studies (secondary data sources). Thus it is expected to obtain settlement patterns and building patterns/building arrangements along with

their changes. In an effort to obtain a pattern of use of building materials, direct observations are made on the use of building materials. The building that was observed was chosen for the building that had the least change in the development to the present, with the hope that traditional building materials would still be visible and observable. Considering that buildings that are still intact (traditional) do not fully exist, they are integrated with interviews with community leaders to obtain information about patterns of use of building materials. Observation starts from the fence of the yard, house, and supporting buildings such as rice barns that are widely available in this village.

In addition, at a glance, it will be observed how people's life patterns in utilizing energy, utilizing existing resources in the context of the greenhouse effect (Anh 1984, Arief 1988, Bryant 1989). With the general view that the more energy used, the higher the greenhouse effect is produced. Similarly, the use of building materials, the more diverse the use of building materials, the higher the greenhouse effect it causes. Included in the pattern of waste management and the resulting waste. Thus also carried out an observation of how the back of the house of the local community which is usually used as a landfill, as well as a place to raise pets, such as pigs and chickens. The pattern of solid waste management is also seen to influence the occurrence of the greenhouse effect (Derek 1991, Department of Education and Culture. 1993, Denzin 2009).

RESULTS AND DISCUSSION

The research location is Bongli Village which is part of the Sangketan Village, Penebel District, Tabanan Regency, Bali, Indonesia. Located at an altitude of approximately 500 meters above sea level (BPS Bali 2019, BPS Tabanan 2019). It is a remote village and located in a bumpy or hilly area. Around the village are rice fields and plantations which belong to the local community, where they make a living to make a living. Not far from the village, around three to five kilometers is already a Batukaru protected forest. Local people call it the base cover (protected forest). The location of Bongli Village in more detail is as shown in Figure 1.

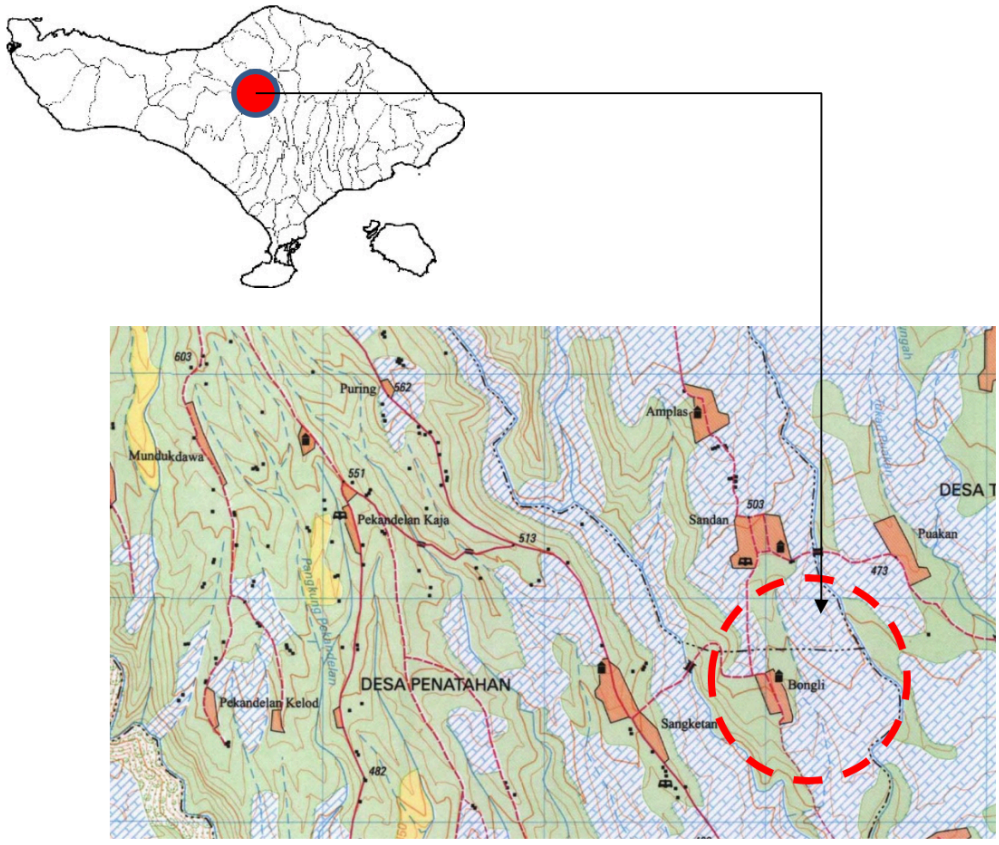

Figure 1. Location of Bongli Village, Tabanan Regency, Bali
Source: RBI Map, 1991.

Field observations show that the settlement patterns of the Bongli Village community are like that of a mountain village generally surrounded by rice fields and plantations. Public facilities for the village are located at the end of the village in the form of the Village Temple and *Bale Agung*, as well as the Dalem Temple which is located downstream of the village. The grave facility is located in the downstream part of the village (south /kelod), while Puseh and Bale Agung temples are located in the upstream (north /*kaja*) village. The two ends of the village are connected by village roads between five and six meters wide. Besides functioning as a link, the village road also functions as a social communication space for the local community. According to public figures that when motor vehicles are not crowded, every day or evening the community will gather in front of kori while stroking domestic chickens (confinement), or just participate in a discussion together. Not only are the co-prisoners having a discussion, but other communities also take part in giving their opinions on the issues discussed. Thus, the social problems in the village will get ideas from various groups of society to find suitable solutions (Budiharjo 1983, Dharmayuda 1995, Dwijendra 2009, Nurjani 2020). Such small deliberations can also be only as an expression of views that require collective thought to get a solution.

In addition, the road is also a place to watch shows such as Balinese performance (*arja, jogged*), if there are residents who hold ceremonies at their homes (Bagus 1980, Brubaker 2000). Performances are carried out by building temporary performance venues called tetaring. Besides the function of tetaring as a place for displaying and hanging lights, it also forms a border that gives boundaries and norms between the audience and the performance organizer.

Village roads are also temporary spaces where religious ceremonies are held for the benefit of the village. The day before *Nyepi* (silent day), the highway was also used as a place to prepare for ceremonies in the form of slaughtering calves, and holding ceremonies by making buildings for ceremonies (*asagan*). Thus new spaces will be formed for the ceremony. But after the ceremony was completed along with the dismantling of the *asagan*, the space will disappear and the road will function as usual. Likewise, during the *ngerebeg desa* ceremony the road will become new spaces formed by the ceremony facility. During the three days of the *ngrebeg* ceremony during which the road space will change its temporary function as a place to hold the ceremony.

However, with the increasing income of the community, more and more people have motorized vehicles both two-wheeled and four-wheeled (cars). On the other hand, traditional spaces do not prepare space for storing vehicles, so that during holidays when the community is moved back to their villages, or when there is a ceremony for a resident, the road will change its function to become a motorized vehicle parking area.

The settlements are located on the left and right side of the road (east-west road) which all go to the village road. At first there were only eight entrances (*kori*) to experts. However, due to population growth, now has increased to ten entrances (*kori*). In each *kori* there are various numbers of family heads who live in it. There is one head of a family of residents, but there is also a group consisting of many heads of families who inhabit the yard. With the development of the number of villagers, then some people have built residential buildings in the fields called *pondok*. Nearly half (50%) of the villagers already live in huts where their fields are located (Alit 1996, Adnyana 1998, Adhika 1996, 2010).

The existing condition of the value system adopted seems to be oriented to the height value system, where the high location is considered to be the main while the lower place is considered an insult value (Adhika 1996, 2010, 2020). More clearly as in Figure 2. This can be seen from the location of the sacred place of the family (*sanggah*) located on the side of the highway which is located on a ridge, while the yard where livestock raising (*teba*) is located eastward for the east of the road, and to west for those located on the west side of the road. In contrast to the plains in Bali that apply the *sanga mandala* values (Figure 3) so that the *sanggah* is generally located in the main space (*kaja kangin*) of its yard. Thus, village settlements are protected by *teba* (green belt) in the east and west of the village.

In addition to teba, as a green open space, between the rows of houses and other rows of houses there is also an empty space that is unyielding to build buildings in that location (Parisada 1968, Parimin 1986, Adhika 1996, Dwijendra 2008). Local people call the place as cast corals. For generations the yard owner has not dared to build a building, either later after there is no other choice. In today's modern settlements many also apply empty spaces

such as cast corals, in an effort to anticipate or isolate in the event of a fire hazard. In addition, empty spaces can also be used as space to circulate air so that the environment is not too hot and without air flow. In addition, the limited open space in urban settlements makes green open space very meaningful for the residents. This condition is seen in every green open space that functions for the public in urban areas becomes congested during leisure time in the afternoon.

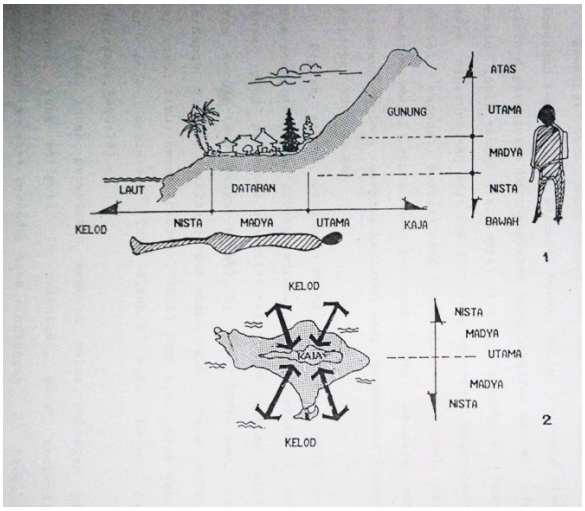

Figure 2. Main Value Based on Height
Source: Adhika, 1991.

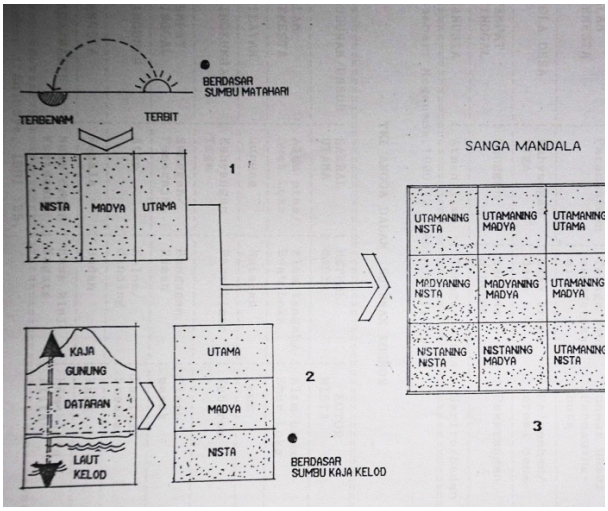

Figure 3. Sanga Mandala
Source: Adhika, 1991.

Patterns of spatial planning and buildings in the yard units have one system in common with each other. In each unit of the yard from the entrance to the use of its space is a sacred place (*sanggah*), then the number of housing units depends on the number of family heads who occupy, then the open space for gardening and raising livestock called *teba* (First Level 1991, Wood 1983, Eiseman 1989, Gelebet 1986). The condition of spatial planning on the other side of the road will have similarities but opposite from the direction of the road. Thus the road is likened to a mirror from the other side (Pitana 1994, Pichard 2006). The arrangement pattern for yard units can be illustrated as in Figure 4.

In addition to the use of space based on the east-west direction, in one-unit yard is also divided into two zones, namely, in the upstream (north/*kaja*) is a residential building zone, and in the downstream (in the south/*kelod*) is a zone where the granary rice (Hobart 1978, 2001, Hobsbawm 1983, Swellengrebel 1984). In the residential building zone there will be buildings that function as kitchens (*paon*) and multipurpose buildings (*Bale Gede*) in sequence from north to south. Next is the zone where the rice granary is built. In this zone it is a place for rice barns for families who live there, as well as families who live in the garden (*ngubu*). Thus the number of existing granary buildings will be more than the number of family heads who live in the yard. In line with the development of time, the family's granary who lives in the garden has been moved to the garden. However, some still leave the barns in the village.

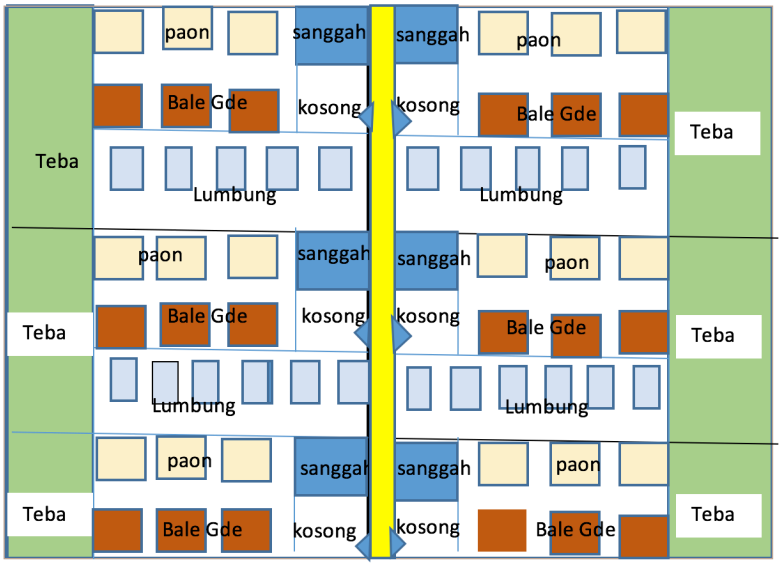

Figure 4. Yard Unit Arrangement Pattern
Source: Author Analysis, 2019.

With this pattern, then one household head in one-yard unit will have a building *paon*, *bale gede*, and one or several rice barns. Thus sequentially lined to the side, the amount depends on the number of household heads of residents of one-unit yard. Between the building and the building is an empty space that is wider than the water from the roof of each building. This condition will allow adequate air circulation. In addition, the distance social relations are also used as a place to circulate between buildings, and circulate between yard units. With such arrangement there is no boundary between the yard and between houses. These spaces provide freedom of interconnection, mutual control, and mutual understanding with each other.

Structuring of building units is made in a scattered manner, and each building has a relatively small dimension, thus giving impact to the natural lighting and ventilation system. This contributes to saving energy usage, especially to increase residential comfort. It would be very different when compared with existing buildings in the city. Building conditions that are close to one another and optimization of the use of available spaces, have resulted in obstacles to the movement of healthy and fresh air. To get the flow and condition of fresh air, we need electronic equipment that requires no small amount of electrical energy. In addition to requiring electrical energy, the use of room conditioning has resulted in the surrounding environment becoming hotter due to exhaust gases from the room conditioning machine. This will impact on other occupants who also tend to use room conditioning. The use of more roaring conditioners will cause more heat discharges which result in the use of more energy as well. In addition, the use of engine cooling materials (CFCs) air conditioning and refrigerators will be able to increase the occurrence of the greenhouse effect.

The dimensions of the *paon* (kitchen) building are approximately 4 meters wide and 5 meters long. Relatively small dimensions are used for cooking and bed activities (multipurpose). The upstream part is used as a fireplace, and downstream is used as a porch. For those who have many families will use the porch as a bed. Because in the upstream section as a bed, the building is made somewhat closed with a wall around it. Only those parts that need open wall light, such as near a cooking stove, or near a bed. The building is covered with walls because of its function as a bed that does not require a lot of lighting, while the furnace is made of windows to illuminate cooking activities. In the porch, the building is made semi-enclosed. On the left/right side are generally made half of the wall and the remaining walls can be dismantled pairs. This is done because the porch serves as a multipurpose room. If there is no activity wall insulation is installed, and if there is a ceremony, the wall will be opened. Although the building is closed, the pattern of air circulation is well maintained. Because traditional buildings use poles, between the walls of the building and the roof there is an empty space around the building. This space provides flexibility in the circulation of fresh air from wherever it comes. With this wisdom the use of air conditioning is

not necessary at all. Especially at the height of this village the air is cool, and is comfortable for residential. This condition can reduce the use of electrical energy both day and night.

Paon building in addition to functioning as a place to cook is also a place to store goods, also a place for labor. Local people have applied simple technology to avoid humidity and in the context of building functions. Building foundations are generally made using stone and soil as the floor. An altitude of 60 cm to 100 cm above the surface of the yard is predicted as an effort to reduce humidity and the natural process of activities in the kitchen, and childbirth. Activities in the kitchen that are associated with elevated water provide opportunities for the natural process of absorption by the floor element. Therefore, even though they do not use ceramics, the kitchen floor is never muddy. Likewise, in the birth process, there will be adequate absorption with these heights. This certainly can reduce the use of energy in the residential process.

Another traditional building is the *bale gede*. Dimensions range from 4.50 cm x 4.50 cm. Also relatively small dimensions. 12 pillar building. Functioning as a multipurpose building, such as: the place of the death ceremony, the birth ceremony, the marriage ceremony, the bed of the parents, the place to carry out daily activities. The building is only walled on two sides only, the rest is a wall that is not permanent and can be dismantled pairs. If there are ceremonial activities the walls which are not permanent will be demolished so that the ceremonial activities can take place properly. Because the dimensions are relatively small and half-open buildings, then during the day will utilize natural lighting. Likewise, the air conditioning system. Between the roof and the wall there is adequate space for air movement on two sides, while the other two sides are open. Thus no artificial ventilation is required for residential comfort. With this wisdom, the use of electrical energy will be less compared to compact and large buildings, especially those in urban areas. The illustration of the *bale gede* building is shown in Figure 5.

Granary or *jineng*, located in the downstream zone. The main function of the building is as a place to store rice. However, there are daily activities that are often done in this building. There are also those who use this building as a storage place for caged chickens (roosters), especially at night. If the owner of the granary conducts religious ceremonial activities, this building becomes one of the places to prepare the facilities and infrastructure of the ceremony. Included in the activities of proclaiming the interests of the party carried out by the owner or neighbor in the unit yard. The building is open and more often used during the day. Thus this building does not need electricity during the day. If there are ceremonial activities, this building will be equipped with temporary lighting. Therefore, this building is energy efficient and can be called a building that is environmentally friendly. Illustration of the image of the granary/*jineng* is like Figure 6.

Figure 5. Bale Gede Building
Source: Survey, 2019.

Figure 6. Granary/Jineng Buildings
Source: Survey, 2019.

The use of building materials in the yard or village unit initially made use of existing local potential. Road and yard dividing walls are made using stone as a foundation material, *popolan* soil as a wall material, and bamboo as

a roof frame, and straw as a roof covering material. These materials are almost all taken from the surrounding environment so that no special transportation is required. Likewise, the *paon* and *bale* building's roof material is thatch grassland, its walls are *popolan* soil which is sometimes mixed with rice husk, and its foundation utilizes river stone and soil. Thus the surrounding material gives color to the architecture of community buildings. Utilization of local materials has reduced the movement of building materials elsewhere. As it is today, buildings are brought in from far away and thus require transportation. Transportation will use petroleum fuels which can affect the exhaust gas output. Exhaust gas will be able to accelerate the greenhouse effect. In addition, the utilization of this energy will affect and can disrupt conditions in the mining area, or generally reduce the quality in the vicinity of the mine environment. Thus there will be a reduction in the use of electrical energy, which also means reducing the generation of the greenhouse effect.

In addition to transportation, the use of natural materials such as alang-alang roofs can act as a barrier to the heat of the sun that enters the house during the day, as well as storing warm at night. Thus the occupant's response to the use of building materials is not too hot during the day, and not too cold at night (Parimin 1986, Ngakan 2017, Nutrisia 20180). The use of roofing materials and building wall systems can reduce the use of air conditioning, which also means less use of electrical energy. Reduction in electrical energy also means a reduction in the greenhouse effect.

Likewise, the granary building. Because of its function as a place to store rice, the roofing material technology uses a mixture of reeds and fibers. This material in ancient times was very abundant around the village. There is even an area whose plants are dominated by palm trees called Karang Jaka (land that is overgrown with dominant palm trees). Almost all of the land is overgrown with palm trees, with heights reaching 20 - 30 meters. This roofing material is installed alternately between reeds and fibers. From the results of public speaking, the combination of this material can last up to 60 years. It can be concluded that the use of durable roofing material is due to the function of the building as a place to store the main food. With this material combination it is hoped that the conditions of rice stored in it will be more stable and more durable. In addition to their own interests, rice can also be used when carrying out religious ceremonies. There is a public view, that the longer the rice is stored, the more self-esteem is raised.

With the development of technology and traditional building materials difficult to obtain, the use of modern materials such as asbestos, zinc, and tile has been widely used. In addition to utilizing energy for transporting and accelerating the greenhouse effect, the use of zinc roofs, asbestos and roof tiles are said by the public that the use of modern materials also has weaknesses. In the rainy season the conditions in the building will be more humid, and in the summer it will be too hot for rice storage. Also thankful that now there are not many people who save in large quantities. When using a reed roof and palm fibers there will be a balance of temperature between summer and winter (Kaler 1983, 2005, Koentjaraningrat 2005). This is due to the fact that the roof of the mixture functions more as a coaca isolator, so that the summer music is not too hot, and in winter it is not too cold.

The traditional use of yard pavement is also done by utilizing materials around the village. Building materials used are river stones that are installed in such a way as to cause aesthetic value in addition to functioning as pavement. The stones are just installed in such a way, so that among them there are still sidelines for water absorption in the rainy season. Aside from being absorbed by water, this condition still allows the growth of grass between the stones. Thus, in the rainy season the surface water flow is not too much because some of it seeps into the ground, while in the dry season it is not too hot because there are still gaps between the rocks.

The most downstream part of the road is *teba*. The *teba* section serves as a place to dispose of garbage, keep livestock (pigs, chickens, ducks, sometimes cows), as well as household plants. Because it is a hilly mountainous area, the local people are familiar with the simple technology of holding land (*taku*) and making sledges (*parigi*). *Taku* are generally made from natural materials, such as trees, while *parigi* is made using stone and palm fiber. The stone is used as a barrier, while the fibers are used as water pores in the rainy season. This will prevent the landslide in the rainy season, which means it can save energy in it. Another advantage is that plants can still live on the sidelines of the rocks arranged. This and reduces the impression of hard and stiff on the joint.

CONCLUSION

The results of the discussion show that in the spread settlement pattern there will be open spaces between elements of the settlement. This will provide spaces for wind movement so that energy use can be reduced. With the reduced use of energy, the greenhouse effect can qualitatively be reduced. Open spaces have also provided an exchange between the needs of residents and the environment so that they can support each other's survival.

In addition, structuring buildings based on local local wisdom can also reduce the amount of energy used. Utilization of closed and open spaces in accordance with their functions has been able to reduce qualitatively the amount of energy used in utilizing local environmental/climate conditions.

Based on the results of field searches and discussions with community leaders, the use of building materials in the local village environment will reduce the amount of movement needed to mobilize these materials. Thus the use of energy for movement will be less too. Therefore, the use of energy will be less too.

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Enhancing Physical, Mechanical and Thermal Properties of Rubberized Concrete

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Abstract
This research aims to develop a low density concrete, characterized by high porosity and reduced thermal conductivity with slight to no compromise over strength, employing scrapped waste tires. Although, literature on the topic is available that addresses benefits and drawbacks of rubberized concrete, this experimental work was formulated to suggest an optimum dose of crumb rubber that imparts sufficient strength and workability in addition to insulation and low weight. Four types of specimens were cost and tested, containing 0, 5, 10 and 15% crumb rubber as partial replacement of sand in ordinary concrete, using ASTM standards. Specially constructed heat transfer measurement device was used to find out the thermal conductivity of the specimens. Scanning electron microscopy was carried out to examine the micro-structure of rubberized concrete. Results reveal that thermal conductivity and density lower by 30% and 15% respectively and porosity increases by 34% at 15% partial replacement of sand by rubber. Higher concentration of voids along the interface were observed at 15% replacement indicating poor bonding and a weaker ITZ, leading to reduced strength. Based on the results, 5% optimum dosage is recommended, which enhances porosity by 5%, compressive strength by 5.5%, and reduces slump by 16%, thermal conductivity by 16% and density by 2% respectively.

Keywords: Concrete, Waste Rubber Tires, Thermal Conductivity, Density, Strength, Porosity

1. Introduction

The effective use of recycled and waste materials in construction applications and the solution of environment problem by recycling have attracted many researchers in the recent past (Ahmed, Khitab, Mehmood, & Tayyab, 2020; Bolden, 2013; Hassan Riaz, Khitab, & Ahmed, 2019; Jalil et al., 2019; Riaz, Khitab, Ahmad, Anwar, & Arshad, 2019). The rate of production of rubber around the globe varies from country to country. More than 3.6 million tons of rubber is produced by United States per year. Iran and Malaysia produce 0.1 and 0.2 million tons of rubber each year, respectively (Abdollahzadeh, Masoudnia, & Aghababaei, 2011; Bakri, Fadli, Bakar, & Leong, 2007). As shown by studies, rubber tires after their lifespan, contain materials, which cannot be decomposed in an environment-friendly manner and lead to severe environmental problems. Rubber can be decomposed via burning, but it adversely affects the atmosphere. Alternatively, these scrap tires can be used in concrete as replacement of aggregates (A.Sofi, 2018; Herrera-Sosa, Martínez-Barrera, Barrera-Díaz, Cruz-Zaragoza, & Ureña-Núñez, 2015; Sohrabi & karbalaie, 2011; Toutanji, 1996). The demand for tires continuously increases as

the number of vehicles increases. As the scrap rubber tires are not easily biodegradable, therefore it is acute challenging for the industries to handle such waste. On the other hand, the natural aggregates used for making concrete are finite and are rapidly dwindling. The frequent use of conventional concrete also necessitates a careful selection of the constituent materials for avoiding undesirable consequences like alkali-silica or alkali carbonate reactions and many others (Anwar Khitab & Anwar, 2016; Munir, Kazmi, & Wu, 2017; Munir, Kazmi, Wu, & Patnaikuni, 2018). Following paragraph highlights some of the important works, regarding use of waste rubber particles in concrete.

Kaloush et al. studied the addition of crumb rubber as substitute of air-entraining agent for concrete, using higher rubber contents (30, 60, 90, 120 kg/m^3 of concrete) (Kaloush, Way, & Zhu, 2005): They have reported that the addition produces air-entrained concrete with reduced unit weight, compressive and tensile strength. In addition, the rubberized concrete shows a ductile failure. Benazzouk et al. have investigated the effect of powdered tire rubber as addition to cement paste on both the physico mechanical and water absorption properties (Benazzouk et al., 2007): They have reported that the composite satisfies the basic requirement of construction materials. Ghedan et al. studied the partial replacement of coarse aggregates by chipped rubber particles treated with and without saline (Ghedan & Hamza, 2011): They have reported a reduced thermal conductivity with rubber aggregates. In addition, they have reported that saline treated aggregates recover some of the loss in compressive strength. Yusuf et al. proposed a model that can predict the compressive strength of rubberized concrete and aid structural designers who are considering rubberized concrete as a promising alternative to conventional concrete in seismic zones (Youssf, ElGawady, Mills, & Ma, 2014). Xue et al. investigated the use of crumb rubber for enhancing the energy dissipation capacity of concrete (Xue & Shinozuka, 2013): Their work revealed that the damping coefficient enhanced by 62% and the seismic response acceleration reduced by 27%. Khalid et al. studied the effect of crumb rubber on workability of concrete (Khalid & Hameed, 2015): They have reported zero slump at 40% replacement of sand by crumb rubber. Aslani et al. investigated the effect of rubber particles as partial replacement of fine and coarse aggregates on properties of concrete (Aslani & Khan, 2019): They have reported enhanced deformation and energy absorption with the rubberized concrete with reduced mechanical strength and workability. Oprişan et al. studied rubberized concrete short columns (Oprişan et al., 2019): They confined the columns with Aramid fiber-reinoforced polymer jackets for restoring the loss of compressive strength due to rubber particles. They have reported enhanced peak stresses and axial strains with rubberized concrete. From previous studies, it is quite clear that inclusion of rubber particles reduces workability and mechanical strength. The loss of workability led the researchers to employ some viscosity modifiers and supplementary cementitious materials, while employing rubber particles in concrete (Güneyisi, 2010; Topçu & Bilir, 2009). The loss of mechanical strength was compensated with some supplementary cementitious materials and special techniques (Elchalakani, 2015; Ghedan & Hamza, 2011; Güneyisi, 2010; Oprişan et al., 2019). Many other researchers have termed rubberized concrete as a good insulating materials with lower density but at the same time have also mentioned it a low strength material (Benazzouk, Douzane, Mezreb, Laidoudi, & Quéneudec, 2008; Marie, 2017): Ironically, all major studies for examining thermal conductivity and/or strength have used high volume ratios, starting from 10%. Although, higher thermal insulations were obtained, but they were also accompanied by drastic lower strength. Additionally, the previous studies present some segregated knowledge about the topic: Either durability or strength with physical characteristics were the main objectives (Benazzouk et al., 2007, 2008). Also, microscopic analysis of the specimens is missing in most of the past studies.

This research project was intended to investigate the effect of lower percentages (5, 10 and 15%) of rubber particles on physical, mechanical and durability aspects (all in one) of ordinary concrete. The study is supplemented with a rigorous microscopic analysis too. The overall intent was to enhance knowledge about the rubberized concrete and to develop light weight material with low thermal conductivity and reasonable strength and workability.

2. Materials and Methods

Both control and rubberized concrete samples were casted using the local cement, sand and coarse aggregates as per standard ASTM procedures (ASTM, 2013). A grade C-53 cement was used and its chemical composition and physical properties are given in Table 1.

Table 1. Chemical and physical properties of cement

Chemical Composition of cement used		Physical Properties of Cement	
Gypsum	1%	Specific gravity	3.15
Silica	30%	Normal Consistency(%)	30%
Iron Oxide	2%	Soundness(mm)	2%
Magnesium Oxide	1%	Fineness(%)	1%
Aluminum Oxide	5%	Initial Setting time (minutes)	30
Lime	61%	Final Setting time(minutes)	610

Lawrencepur river sand was used as fine aggregates. Coarse aggregates were acquired from the renowned limestone quarry of Margalla near the capital Islamabad and its characteristics are shown in Table 2. The selected quarries are well-documented, tested and contain inert materials. All constituents were carefully decided for avoiding any unfavorable consequences as mentioned above.

Table 2. Physical properties of fine aggregates

Physical Properties of Sand		Physical Properties of Coarse Aggregates	
Specific Gravity	2.69	Specific Gravity	2.48
Fineness Modulus	2.72	Bulk Density(kg/m^3)	1598
Bulk Density (Kg/m^3)	1500	Dry rodded density(kg/m^3)	1610
Dry rodded Bulk Density(Kg/m^3)	1850	Water absorption(%)	1.49
Water absorption(%)	3.88	Void(%)	34.11
Water Content (%)	2.01	Impact Value(%)	13.20

Crumb rubber was produced in the laboratory by shredding the waste tires and scrubbing with sandstone. The finished product is shown in Figure 1. The physical properties of crumb rubber are mentioned in Table 3.

Figure 1. Crumb rubber

Table 3. Physical properties of crumb rubber

Specific Gravity	1.66
Color	Black
Surface	Moderately rough
Fineness Modulus(%)	4.1
Water absorption(%)	1.25

By comparing Tables 2 and 3, it is quite clear that crumb rubber should result in light-weight finished products owing to lesser specific gravity than that of the replaced sand. From particle size analysis, it was observed that crumb rubber contains relatively coarser particles, and have lesser water absorption than sand. The low water absorption values add to the quality of concrete.

The sieve analysis of sand and sand-crumb rubber mix as per standard ASTM methods are shown in Figure 2. *The mix was prepared in a way that sizes remain within the limits, defined in ASTM standards for fine aggregates* (A. Khitab, 2012).

A

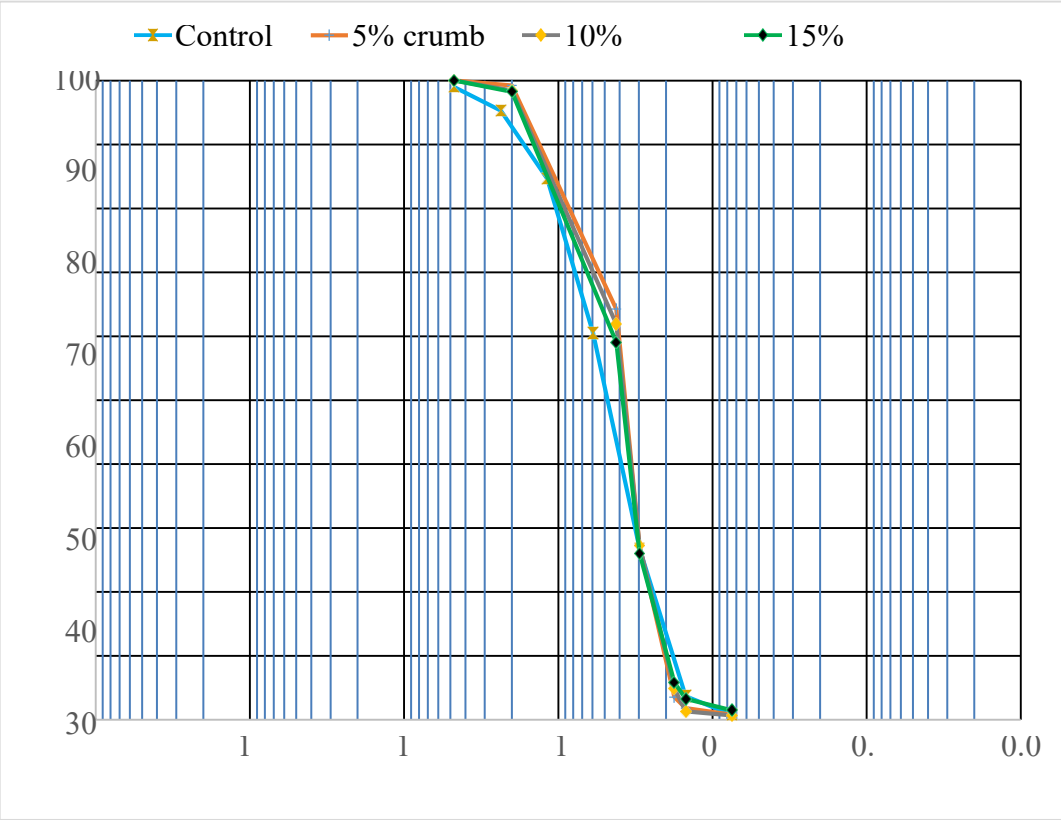

Figure 2. Sieve analysis of sand

thorough mix design was prepared for both the control units (Co) and the modified units (partially replaced sand) with notations as C5, C10, C15. After a series of initial trials, the mix design was selected as 1:1.56:3.12 (cement: sand: coarse aggregates), with water to cement ratio of 0.45. The composition of the mixes is shown in Table 4.

Table 4. Concrete compositions (per cubic meter of concrete)

Sample	Cement (kg)	Sand (kg)	Crumb Rubber (kg)	Coarse Aggregate (kg)	Water (l)
Co	390	608	0	1217	175.5
C5	390	578	30	1217	175.5
C10	390	547	61	1217	175.5
C15	390	517	91	1217	175.5

The samples after mixing properly were casted carefully according to ASTM C-192 (ASTM C192 /C192M, 2019). The molds were buttered properly by applying diesel oil and were thoroughly cleaned by using sand paper. The Casting was done into three layers. Each layer was tempted 25 times. The molds were removed after 24hrs and the specimens were engraved by the date of casting as an identity and then were put inside the curing tank having clean water.

3. Results with Discussions

3.1 Workability

A true slump was observed in all the fresh specimens regardless of rubber quantity. The results are summarized in Table 5.

Table 5**.** Variation of Slump with rubber content

Specimen	Slump (mm)
Co	48
C5	40
C10	31
C15	22

From the results as given in Table 5, it is clear that the workability decreases with rubber content. The reduced workability is attributed to lower specific gravity of rubber particles, which hinder the compaction efforts in a slump test. The results are in close coordination with the previous studies (Khatib & Bayomy, 1999).

3.2 Density

Fresh and hardened densities of the specimens are mentioned in Table 6. It can be seen that both the densities decrease with increase in rubber content. The effect is attributed to the lower specific gravity of the rubber content as compared to that of sand, and the induction of voids due to poor compaction. The induction of voids was confirmed from microstructure of the specimens, which is mentioned in the coming paragraphs.

Table 6**.** Variation of fresh and hardened densities with rubber content

Specimens	Fresh Density(Kg/m^3)	Hardened Density(Kg/m^3)
Co	2512	2448
C5	2455	2404
C10	2176	2278
C15	2008	2098

3.3 Compressive strength

Compressive strength results are presented in Table 7: It indicates that the strength increases from that of the control specimen, by 4% at 5% modification, and then gradually decreases. At 5% replacement, the rubber particles hold cement products in a better way due to its rough texture and flakiness: This was also confirmed through SEM of C5 given in Figure 4. As the rubber content increases, the sample becomes less dense, the rubber particles come in contact with other rubber particles and tend to act like a good shock absorber to withstand the blows during the process of rodding: This in turn does not help reducing the voids and the strength is reduced.

Table 7 Variation of compressive strength (MPa) with rubber content

Notation	3 Days	7 Days	28 Days
Co	10.5	18.2	28.1
C5	11.5	19.9	29.6
C10	11	17.3	26.3
C15	10.3	14.9	22.5

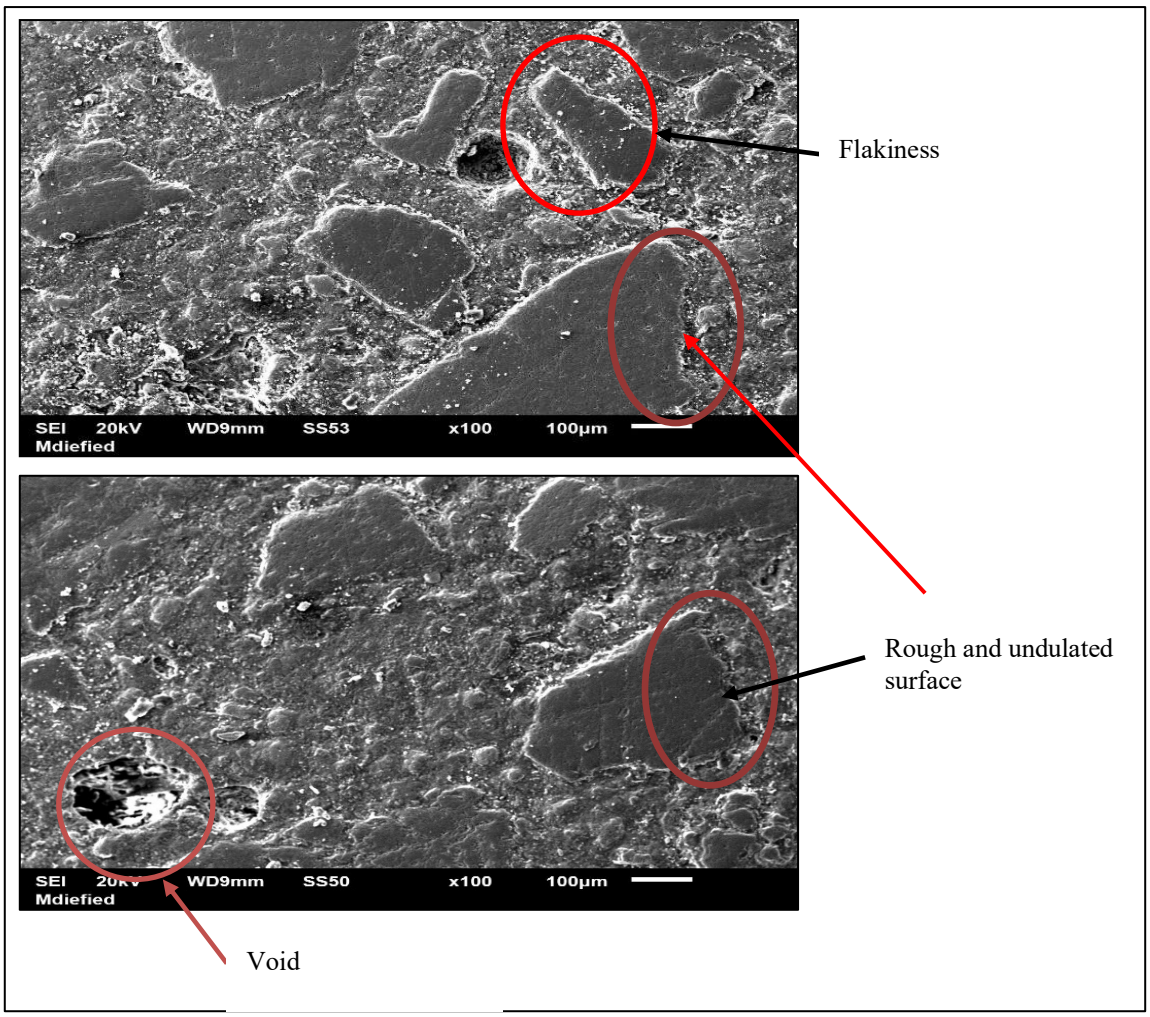

Figure 3. Microstructure concrete with 5% rubber content

Figure 3 shows that the flakiness of the rubber particles and its rough and undulated surface provides mechanical friction with the surrounding cement paste. Also, the rubber particles at lower content seem reasonably distributed in the cement

matrix, with fewer voids: This in turn enhances the compressive strength of the concrete specimens at lower rubber content. However, at higher rubber contents, the rubber particles were seen agglomerated, poorly distributed, and resulting in higher void content: This overcame the beneficial rubber particle shape effect and mechanical friction, and resulted in lowering the strength of the specimen.

3.4 Thermal Conductivity

Thermal conductivity was measured, using a specially built device shown by a schematic diagram in Figure 4 based on the principle of common measurement techniques. The testing specimen was placed between a heat source and a heat sink. The sample was heated by the heat source with known steady-state power input and the resulting temperature drop ΔT across a given length (separation) of the sample was measured by temperature sensors after a steady-state temperature distribution was established. The temperature sensors employed can be thermocouples and thermometers. Thermocouples are the most widely used sensors due to their wide range of applicability and accuracy. The resulting measurement error in ΔT due to temperature sensor shall be less than 1% (ASTM C177-13, 2013).

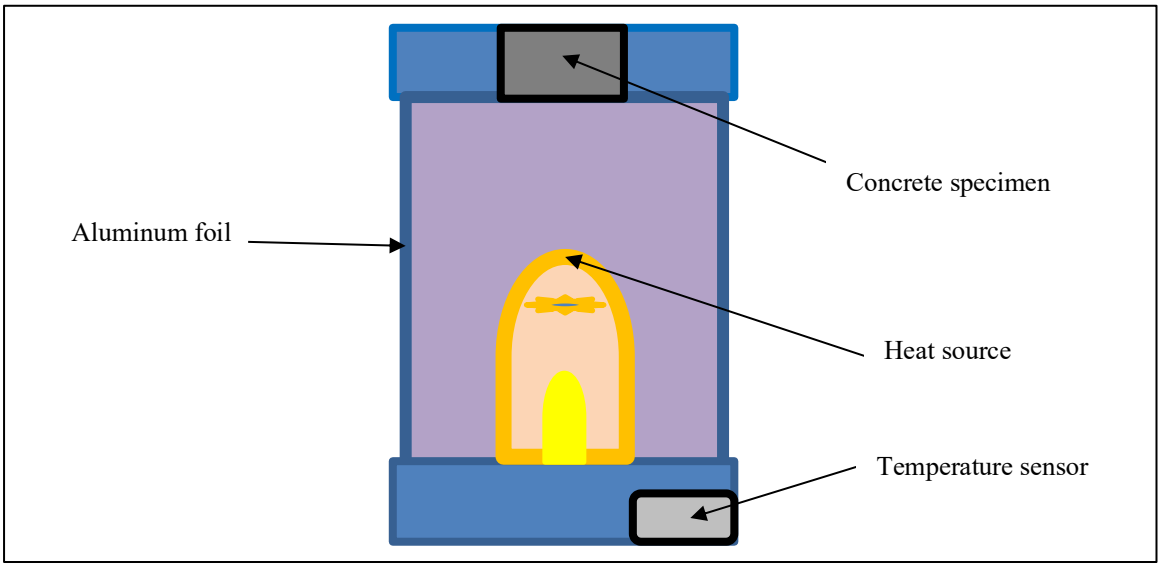

Figure 4. Schematic diagram for thermal conductivity measurement

Thermal conductivity k of the sample was calculated using Fourier's law of heat conduction, as given in equations *(1)* and *(2)*:

$$Q = k.A.\Delta T \quad (1)$$

$$k = Q.L/A.\Delta T \quad (2)$$

In the above equations, Q is the amount of heat flowing through the sample and bears the same units as power, A is the cross-sectional area of the sample, L and ΔT are the distance and temperature difference between temperature sensors, and k represents thermal conductivity. The actually developed assembly with concrete specimens are shown in Figure 5.

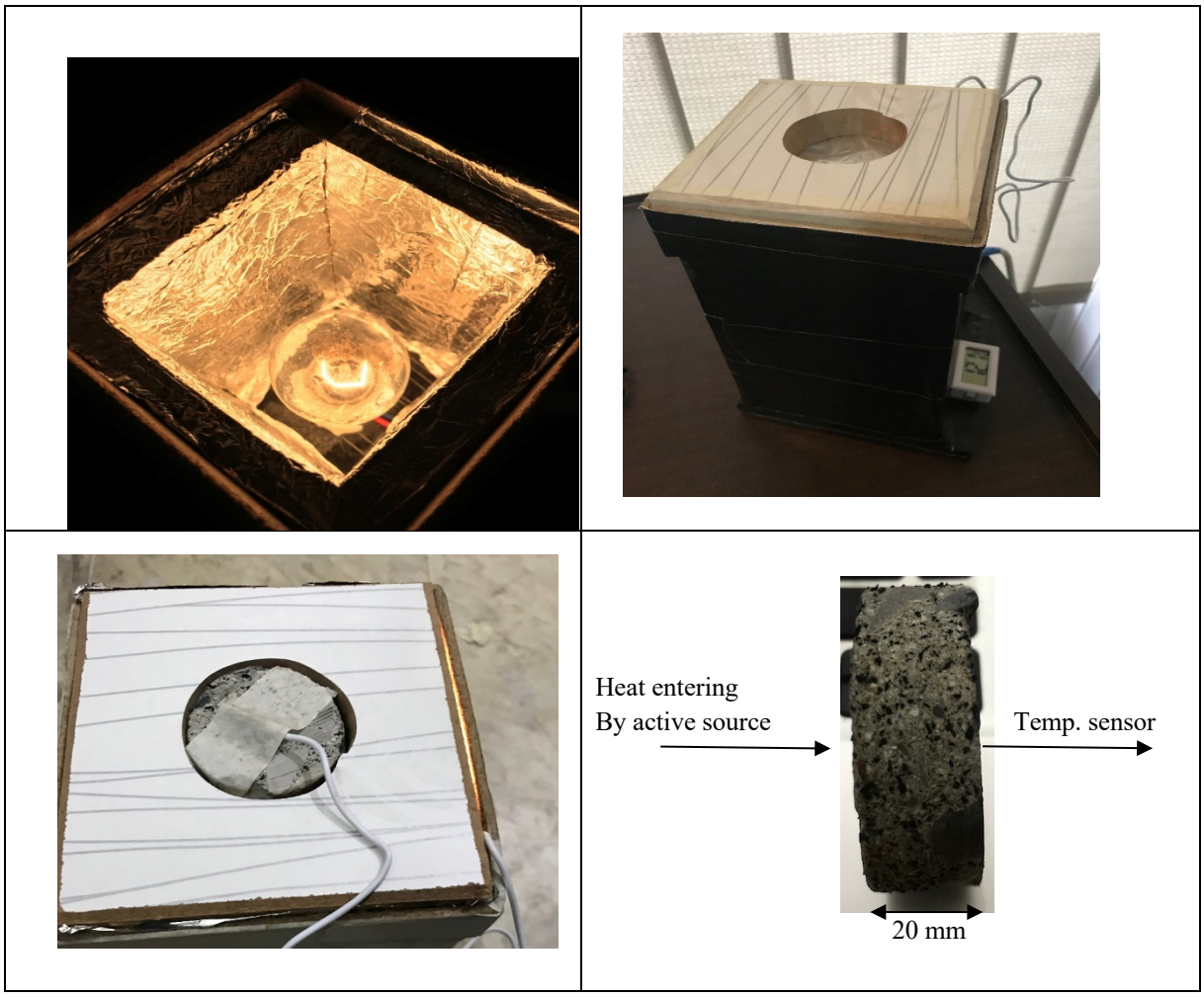

Figure 5. Thermal conductivity measurement device

The variation of thermal conductivity with rubber content is shown in Figure 6. From the figure, it seems that thermal conductivity varies linearly with rubber content. Variation of thermal conductivity with rubber content can be represented mathematically as follows:

$$k = -0.02x_r + 0.995 \qquad (3)$$

Where, k is the thermal conductivity in $W.m^{-1}K^{-1}$ and x_r is the rubber content as percentage replacement of sand. According to Asadi et al., thermal conductivity of ordinary concrete varies from 1-2 $W.m^{-1}K^{-1}$ (Asadi, Shafigh, Abu Hassan, & Mahyuddin, 2018): From the results, it was observed that the thermal conductivity can be reduced by 30% with 15% replacement of sand by rubber content. The decrease of thermal conductivity of concrete can be related to increase in void content and low thermal conductivity of rubber compared to sand. Previous studies indicated that the rubber present in cementitious mixtures increases the air content even without adding air-entraining admixture. Benazzouk et al. reported that air content increases from 2 to 17%, when amount of rubber increased from 0 to 50% (Benazzouk et al., 2007). Air has thermal conductivity of 0.0026 W/mK, which serves to improve the specimen thermal insulation property. The other factor is the thermal conductivity of rubber particles itself. Thermal conductivity of rubber varies between 0.05-0.13 W/mK for particle size range between 1-12 mm. When crumb rubber particles replace sand, which has higher thermal conductivity, the overall thermal conductivity of mixtures decrease. The variation of thermal conductivity as density of concrete is shown in Figure 7.

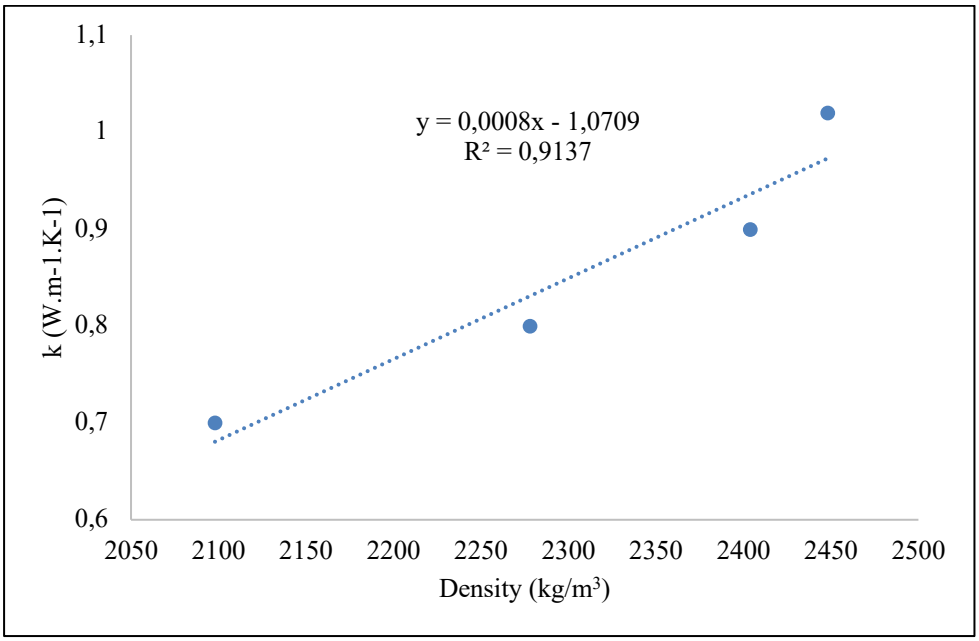

Figure 6. Variation of thermal conductivity as a function of hardened density of concrete

Figure 6 shows that there is a linear improvement in thermal insulation with decrease in density. Control specimens have thermal conductivity of 1.02 $Wm^{-1}K^{-1}$, which reduces to 0.7 $Wm^{-1}K^{-1}$ at 15% replacement.

3.5 Porosity

Concrete comprises a porous heterogeneous structure as it sets: Porosity is an important parameter affecting the durability, freezing and thawing performance and corrosion resistance of concrete (A. Khitab, Lorente, & Ollivier, 2005). Method of vacuum water absorption was used to determine the porosity of concrete (Anwar Khitab, 2005; Li, Dong, Li, & Li, 2015). The results show that the porosity increases with increase in rubber content. The results showed that the crumb rubber worked as the air-entraining agent which can enhance the porosity of concrete.
The porosity was determined at regular intervals, which revealed that the porosity increases as the amount of crumb rubber increases. The results are indicated in Table 8.

Table 8. Variation of porosity with time and rubber content

Time	15 min	30 min	1 hr	2 hr	4 hr	8 hr	16 hr	24 hr	48 hr
C0	4.51	4.949	5.38	5.56	5.98	6.12	6.49	6.78	6.83
C5	4.67	5.46	5.96	6.12	6.26	6.58	6.98	7.12	7.2
C10	5.129	5.88	6.11	6.56	6.82	7.02	7.73	8.01	8.16
C15	5.878	6.23	6.87	7.12	7.42	7.96	8.16	9.07	9.17

Control and C15 specimens, when dipped in water are shown in the Figure 7: C15 shows a lot of air bubbles on top surface, which confirms the presence of air in the modified concrete.

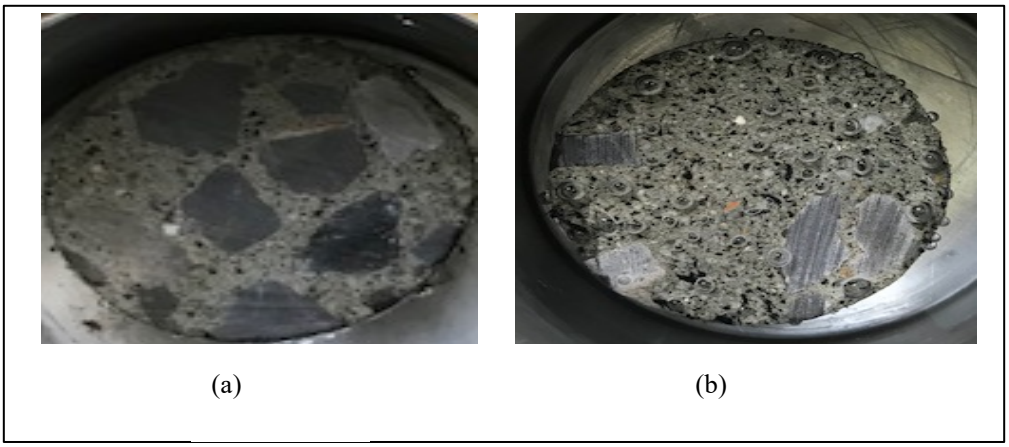

Figure 7. Air bubbles (a) control specimen (b) specimen having 15% rubber as partial replacement of sand

3.6 Interstitial zone

The ITZ is of paramount importance in studying short-term as well as long-term properties of cementitious materials: It is characterized by a thin interface layer that exists between the aggregates and the paste matrix. This is a region of gradual transition of properties, where the effective thickness of the region varies with the microstructural feature being studied, and with degree of hydration. The ITZ of the rubberized concrete (C15) is shown in Figure 8, where the cement matrix is concentrated on right side and the ITZ is on left hand side. It can be seen that ITZ is highly porous.

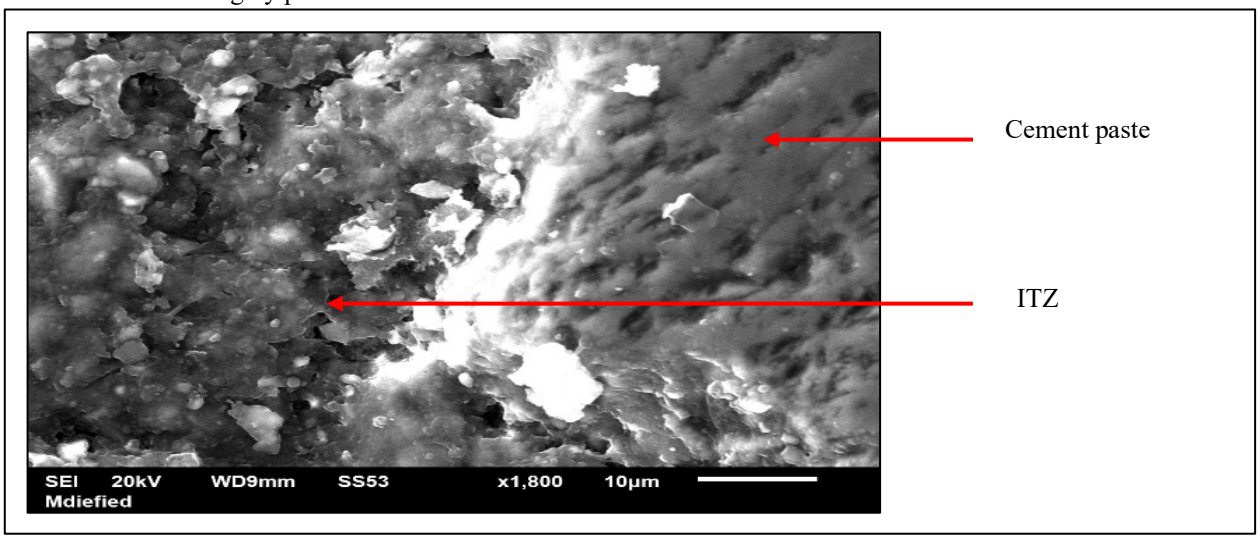

Figure 8. Cement paste and ITZ in concrete containing 15% rubber content

Figure 9 shows the interior of ITZ: It can be seen that the pore inside the ITZ range in size from 1 to several micrometers with connectivity at certain locations.

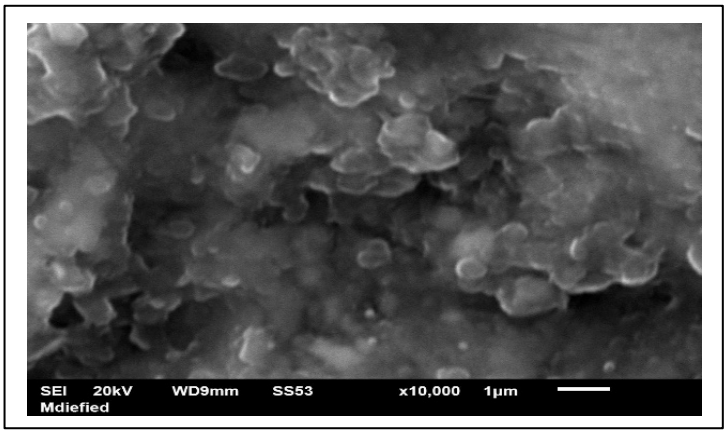

Figure 9. Porous structure of ITZ in rubberized concrete

As mentioned before, the rubber particles have sharp edges and rough surfaces, and as they might enhance friction, they also might entrap air between them and cement paste and increase the pore content as well as their connectivity. Hence the interfacial transition zone of crumb rubber concrete is weak. Weakness of ITZ is more pronounced at higher concentrations, which lead to drastic reduction in mechanical strength of the material, from 28 MPa for control specimens to 22.5 MPa for specimens containing 15% crumb rubber.

4. Conclusions

This research investigated the effect of crumb rubber on the thermal conductivity of the rubberized cement mortar. The thermal conductivity was measured using a specially made device based on the principle of common measurement techniques. From the findings of the experimental work, the following conclusions may be drawn:

This research focused on the effect of crumb rubber on strength, thermal conductivity, porosity and ITZ of the rubberized cement concrete. From the findings of the experimental work, the following conclusions may be drawn:

- The partial replacement of sand via crumb rubber decreases the workability of concrete and ensures a true slump due to decrease in viscosity of concrete mix.
- Compressive strength increases up to 5% partial replacement of sand by crumb rubber by 4%. This is attributed to rough surface and flakiness of rubber particles, which seem dominant at lower concentrations.
- Compressive strength decreases at 10% and 15% replacement levels. Highly porous structure of ITZ was observed at 15% replacement level, which reduced the strength.
- Partial replacement of sand by rubber particles ensures lightweight materials. The density of the concrete lowers by 14.5% at 15% replacement.
- Partial replacement of sand by rubber particles reduces thermal conductivity of concrete. Thermal conductivity lowers by 30% at 15% replacement.
- Partial replacement of sand by rubber particles increases porosity of concrete. Porosity increases by 34% at 15% replacement.
- Rubber particles were observed to entrap air, making ITZ highly porous: This makes ITZ of rubberized concrete, weaker than the control material.
- Based on the results, 5% partial replacement is recommended, which not only reduce density, and thermal conductivity, but also enhance compressive strength and maintain reasonable workability.

Declaration of Conflict of Interests

The author(s) declare(s) that there is no conflict of interest.

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