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E-PROCEEDING OF

1st INTERNATIONAL
E-CONFERENCE ON
GREEN & SAFE CITIES
2022

“Sustaining the
Resilient, Beautiful and Safe Cities
for a Better Quality of Life”

20 & 21 SEPTEMBER 2022

Organisers:



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“ **Sustaining the Resilient, Beautiful and Safe
Cities for a Better Quality of Life** ”

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Perpustakaan Negara Malaysia

Cataloguing in Publication Data

No e ISBN: 978-967-2776-13-0

Cover Design: Muhammad Falihin Jasmi

Typesetting : Ts Dr Azizah Md Ajis

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CONTRIBUTING FACTORS AND MAIN AGENTS AFFECTING BUILDING DEFECTS IN THE COASTAL ENVIRONMENTAL OF MALAYSIA: A QUALITATIVE STUDY

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Abstract

Nowadays, there are many different types of buildings that need to be taken care of, including residential, office, commercial, and other types of buildings. Certainly, a variety of environmental conditions, such as those found on the shore or in a coastal area, play a part and contribute to building defects. In terms of aesthetics and ecology, the majority of people always feel that building near the sea is one of the most comfortable places to live. However, there are certain weaknesses to owning a home in a seaside area, including those defects can emerge more quickly than in a non-coastal environment. Therefore, the objectives of this study were to identify the main agents that contributed to the defects and offered coastal defect prevention to limit future difficulties. There is a need for a proper decision to solve this situation. Literature review, questionnaires and observation were used to obtain data for this study and four case studies have been performed in this research. Saltwater and rainwater, strong waves, and driving rain (monsoon season) were among the most frequent cause of defects in coastal residential buildings. Corrosion, rot on structures, and cracks as a result of erosion are examples of architectural problems. As a result, while performing regular inspection and maintenance on each structure, selecting the appropriate materials can significantly minimise or reduce damages and could improve the building condition in the future.

Keywords: *Environmental, Agents, Coastal, Material, Building Defects, Corrosion, saltwater, Maintenance.*

INTRODUCTION

Nowadays, the construction business is becoming more modern as technologies evolve and flourish around the world, including in Malaysia, and as we can see, there is a lot of construction activity in every location, especially along the coast. Furthermore, defects and failures in buildings arise due to a variety of factors, and building defects remain a key issue that the construction industry must address (Hang, 2016). According to National Building Agency (1985), building defects occur due to design deficiency, poor quality workmanship, because the building was not built according to the original design, or because it is the result of factors that do not fit with the design requirements (Halim et al., 2012). Coastal ecosystems

are locations where land and water come together to form an environment with its structure, diversity, and energy flow. Salt marshes, mangroves, wetlands, estuaries, and bays are among the various varieties of plants and animals that live there. Coastal ecosystems, on the other hand, are extremely vulnerable to environmental changes, and certain places are now battling to retain their diversity as a result of human activity, the introduction of non-native species, and other causes (Council, 2015). However, the weather in the coastal area is occasionally worse than in the rest of the country. As a result, correct coastal building construction and methods should be used in the future to avoid significant problems for the tenants or other people.

In general, there is a lot of work going on along the shore these days, mainly for residential and tourism development. More than half of the world's population now lives near the sea (within 60 kilometres), and this number is growing. Climate change is having a significant impact on most of the world's coastal regions. Coastal regions have been vulnerable to different risks, such as inundation and erosion, as a result of sea-level rise (SLR), which has influenced coastal environments (Williams et al., 2017). The coastline of Malaysia is approximately 4,800 kilometres long, including the coastal areas of Sabah and Sarawak. Malaysia's coastal region is situated on the geologically solid Sunda Shelf. The overall length of Malaysia's coastline is roughly 73 percent of the total length of the country's border.

It is common knowledge that a building defect is one of the most serious issues to which all parties should pay attention. When a structure fails to perform as it should, it can cause a slew of issues for people, particularly occupants. This investigation, which was based on several of studies, found defects in the building of coastal structures. In a coastal climate, materials and building methods should withstand flood and wind damage, wind-driven rain, corrosion, dampness, and deterioration (due to sunlight, ageing, insects, chemicals, temperature, or other reasons) (B2B Purchase, 2018). The same reason frequently causes the fault to occur again at the structure.

LITERATURE REVIEW

Environment Along the Coast

Coastal areas or zones, as stated by (Garten, 2016), are located near coastal seas and associated land regions, and include islands, transitional and intertidal zones, salt marshes, wetlands, and beaches. Many coastal zones are at risk as a result of the negative consequences of urbanisation, industrial pollution, runoff, and waste and sewage discharge. The Coastal Zone Management Act (CZMA) was enacted in 1972 to protect coastal areas from pollution and overpopulation. Nowadays, coastal development is increasing because (Raza, 2016) found that coastal regions have a high value of socio-economic linked activities, including aquaculture and fisheries, physical setting and land use, tourism, environment and natural resources, and other economic situations.

Main Agents of Defects

Defects occur in buildings for a variety of reasons. This is perhaps not surprising when one considers the wide range of materials and techniques used in the construction of the building, differences in condition on building sites and the varied occupational uses of the completed building. The main agents of building defects as mentioned by (Hanafi et al., 2018; Othuman Mydin et al., 2012), are mechanical, electromagnetic, thermal, chemical, biological and natural disasters. As shown in Table 1, illustrates the researcher's understanding of the main agents of defects, which are the source of changes in building materials and elements and adversely affect the material and structure.

Table 1
Understanding of Main Agents of Defects of Material Changes

Main Agents		Changes in the composition or condition of the materials used	Changes in structure form	Changes in shape, size and weight	Changes in appearance, including colour
Mechanical	Forces applied		√	√	
	Ground pressure		√	√	
	Dynamic		√	√	
	Vibration		√	√	
	Wind		√	√	
	Water				
Electromagnetic	Solar radiation	√			√
	Ultraviolet radiation	√			√
	The visible waveband	√			√
	Infra-red radiation	√			√
Thermal	Temperature	√	√	√	
	Fire	√	√	√	√
	Climatic condition	√	√	√	√
Chemical	Water	√			
	Oxygen	√			
	Sulphates	√	√		
	Other chemical agents				
Biology	Human				
	Animal	√			√
	Plant	√			√
	Micro-organisms				
Natural disaster	Earthquake		√	√	
	Tsunami		√	√	
	Flooding		√	√	
	Landslide		√	√	
	Firestorm		√	√	

Water, wind, and wave movement are the three major forces that might create a problem in a coastal structure. There are a few defects that can be caused by these three agents, including saltwater, strong wave, wind & rain (Monsoon Season). As mentioned, the main contributor to the defects from this agent is seawater. The water that makes up the oceans and seas, which cover more than 70% of the Earth's surface, is known as saltwater/seawater. Seawater is made up of 96.5 per cent water, 2.5 per cent salts, and trace quantities of other components such as dissolved inorganic and organic compounds, particles, and a few atmospheric gases (Mackenzie & Et al, 2018).

Building Defects

The defects in buildings occur because of the inadequate or drawback of the original design, the building was constructed without according to the design or with appropriate practice, or the workmanship was below standard, or because the building has been accepted forces. The emergence of defects that will affect the comfort of occupants, such as noise interruption, solar gain, and glare. However, been omitted as it is considered that they do not affect the fabric or the services. To avoid a significant problem in the future, careful attention must be paid to building faults. It can also be described as a flaw or blemish. Deficiency is another name for a defect. As a result, a building defect may be described as any condition that decreases the building's value and performance. A building defect, as described by (Ahzahar et al., 2011), is the consequence of an architect's design error, a manufacturing problem,

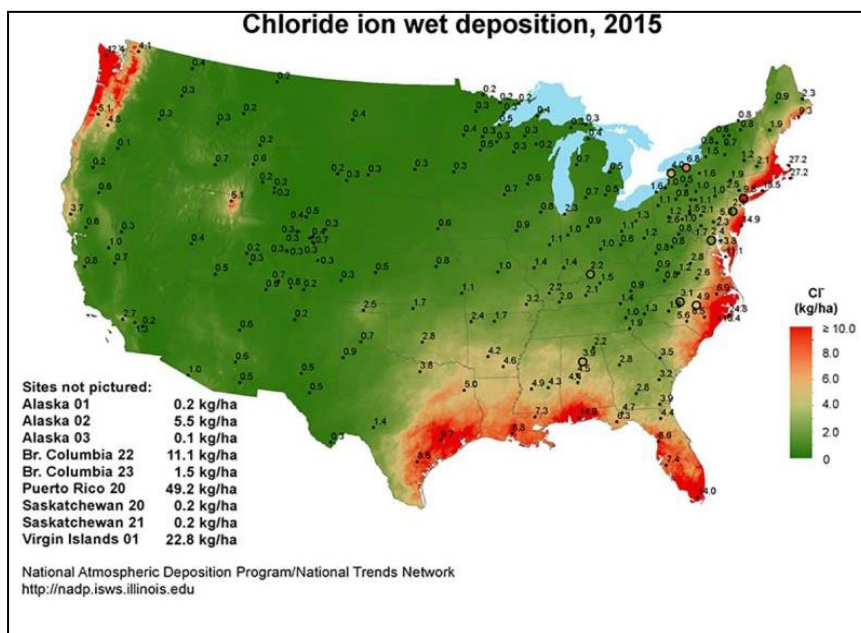
incompatible materials, inappropriate usage or installation of materials, a contractor's failure to comply with the design, or any combination of these factors.

Defects in Coastal Area

Since many residential buildings in coastal areas are exposed to saltwater. Corrosion and deterioration of building elements such as the rebar, window frame, door, and others are possible defects caused by seawater (Mackenzie & Et al, 2018). According to (FEMA, 2011a), corrosion is influenced by a variety of elements, with the presence of salt spray being the most significant difference between coastal and non-coastal areas. Metal corrodes five times quicker in salt water than in freshwater, while metal corrodes ten times faster in salty, humid ocean air than in air with normal humidity. Bacteria in ocean water also devour iron, and their excretions rust (Rodriguez, 2018). This is because one of the factors that influence the corrosion rate in this location is the wind speed and direction (salt air) in the coastal area. Salt-laden, moist air can corrode exposed metal surfaces and seep into any gap in the structure (FEMA, 2011b). Salt air may impact metals more than 50 miles inland, according to studies by the (Poma, 2018) in the United States, and the graphic below shows how corrosion rates vary in various areas. One of the most common causes of concrete structure degradation in coastal environments is reinforcing steel corrosion.

Figure 1

The distance of salt air affects these coastal areas (Poma, 2018)



The next defect that may occur from the saltwater is the decay of timber or also known as timber rot of building in coastal areas. Decay will happen when the timber is exposed to moisture or water and termites attack. Next is the strong wave in the coastal area. This is due to high wind, especially during a monsoon season and it may occur an erosion problem. This factor may affect the natural coastal processes which are also sometimes subject to severe damage by erosion and flooding (Persson, 2015). The erosion problem is capable of threatening a coastal residential building such as big damage to the structures such as cracked, because of the destroying erosion control devices and breaching low-lying coastal barrier islands exposing structures on the mainland to increased flood and wave effects (FEMA, 2011a). Besides, this

also can make a building collapse if it did not control and monitored earlier. Furthermore, due to excessive rains and water flow, concrete constructions will be harmed during the monsoon season. This will effect on the structure, particularly its strength and life cycle. According to (Gupta, 2017), there are a few impacts or defects that can arise as a result of rainwater, such as water entering through seepage or leaking damaging the internal structure through corrosion. It will decrease the structural strength of the structure. Then, due to the increased dampness, fungal growth will appear on the walls, causing a variety of health problems.

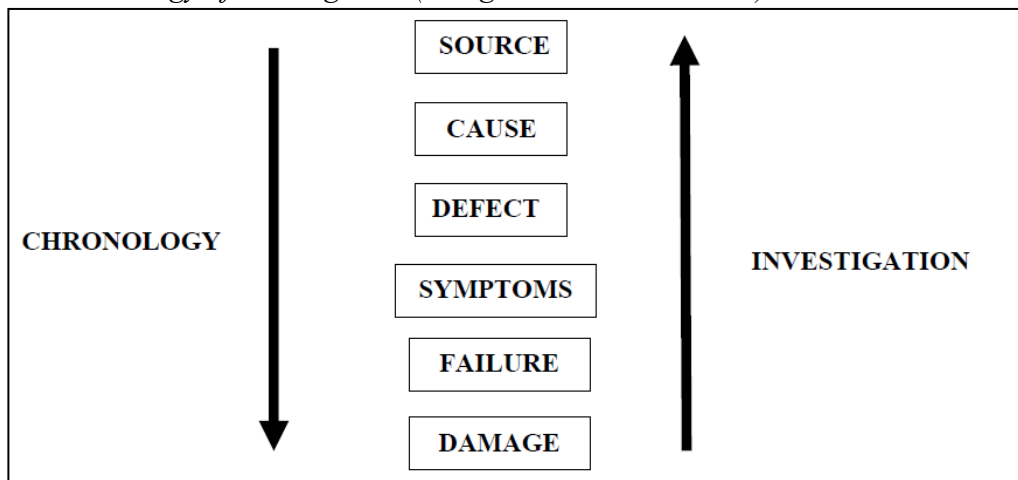
METHODOLOGY

The case study was subjected to observation and qualitative methods. Three locations with four case studies at Batu Rakit beach, Seberang Takir beach, Kelulut beach, and Tok Jembal beach have received the surveys. The site was chosen because the homes were close to the sea. All of the responders had sufficient local experience. The questions started with general matter such as age of building and then moved to the particular issues regarding to the defects have been occurred at the building. As a result, they are familiar with the coastal environment and the usual issues that affect coastal homes. 50 respondents received questionnaires, and all of the questionnaires were delivered during the research investigation. Furthermore, this method requires the researcher's use of instruments to gather data such as a digital calliper, moisture meter, measuring tape, hygrometer and anemometer. The goal of this procedure was to determine the present state of the coastal building's problems. These were carried out at four residences along the shore in order to get photographic proof. The data from this approach was used to analyse the most common problems that occurred during the research investigation. To obtain further information, an interview session with the building's owner was also held.

(Douglas & Ransom, 2013) conducted a chronological study that assisted in the research process as shown in Figure 2. The building's chronology will begin with a source of error that has happened at the structure, which then leads to a cause, which leads to a defect, which manifests as an anomaly or symptom, then failure, and eventually loss or damage (Douglas & Ransom, 2013). The inquiry, on the other hand, will begin with the building damage or failure and work its way to the cause of the defect. This chronology might assist the researcher in determining the causes and types of defects that developed in the structure. The researcher can also determine what the most serious defect is based on this information.

Figure 2

The chronology of investigation (Douglas & Ransom, 2013)



RESULTS

Visual investigations were conducted at various dwellings in three separate case studies in Terengganu, all of which are located near the shore as shown in Table 2. This section has been divided into 5 part which is roof, window, door, wall and external. It easier for the researcher to analyse the defects that have been occurred in the building in the coastal area.

Table 2
Information Of the Buildings Involved

Building	1	2	3	4
Age	More than 5 years	More than 50 years	More than 30 years	More than 70 years
Beach Area	Batu Rakit Beach	Batu Rakit Beach	Seberang Takir Beach	Tok Jembal Beach
Distance from the beach	300m	5m	70m	50m
Building type	One Storey/ Bungalow	One Storey/Bungalow	Two-Storey	One Storey/Bungalow
Building material	Mix	Timber	Mix	Concrete

The climate in Malaysia is tropical, with temperatures ranging between 28°C and 32°C during the day. Furthermore, due to exposure to the annually occurring northeast monsoon, the coastlines of eastern Peninsular Malaysia are directly exposed to the South China Sea's strong winds and dynamic coastal processes, and coastal vegetation acts as a first line of protection against physical elements of wind and wave, (Raza, 2016) remarked that, in comparison to the other east coast states, Terengganu has the longest coast. The evidence that has been taken during the observation also will be discussed in this paper. Because the researcher would immerse herself in the environment where her respondents are, while taking notes and/or recording as proof or information, the observation data collecting approach is categorised as a participatory study. As a result, the researcher conducted a semi-structured interview and took notes while doing the observation. This will assist the researcher in analysing the data gathering and conducting a study discussion.

The observation was carried out in a coastal area ranging 5m to 300m from the beach. Most of this house's metal components are rusted. Upon closer inspection of these four homes, it became apparent that decay, rust, stickiness, and dampness were prevalent problems seen in coastal residences. Rusty at the metal component or material, however, was the most frequent defect. A major contributing factor to rusting residential buildings along the seaside is the reaction from the sea salt and also an improper material choice and careless maintenance. All of these homes revealed the same rust issue, with rust appearing at the hinge, doorknob, electrical components, lockset, and windows. Next, a common problem that the owner faced was sticky due to salt water. Their building will be sticky, particularly on windy days. It will be sticky inside the building, especially on its furnishings. In these four homes, salt water caused the floor, table, and sofa to be damp and sticky throughout the inspection. This can be the factor that causes rust at home because salt always occurs in the building. Figure 3 showed the sample outcomes and an explanation of the observation.

Figure 3
Condition and Defects found on Finishing Material Concerning Building at Coastal Environment

Building 1

Corrosion of Louver windows



Corrosion of Door Hinge



Building 2

Corrosion of electrical equipment and door hinge



Decay on the timber wall and sticky surface (sea salt).



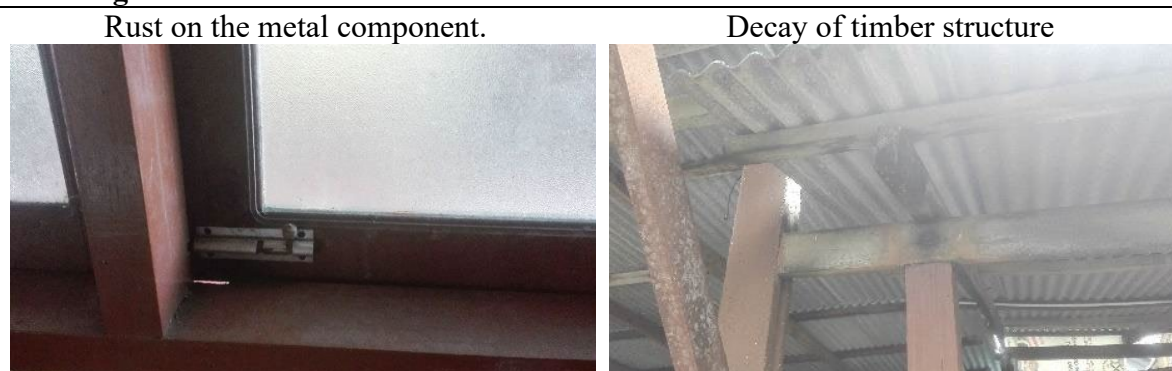
Building 3

Peeling of the paint due to dampness and sticky surface (sea salt)



Corrosion of Louver windows



Building 4**Table 4**

Summary of Questionnaire survey on Defects and Main Agents Affecting Building in the Coastal Environment

Elements	Respondent experienced defects (%)	Factor	Agents	
Roofs	Decay	96%	Chemical	Water & Sulphates
	Missing Roof	96%	Mechanical	Wind
Windows	Decay	80%	Mechanical	Water (salt air)
	Termites attack	82%	Chemical	Water & Sulphates
	Window	40%	Mechanical/Biology	Micro-organisms/wind
	Damage	40%	Biology	
Door	Rusty	90%	Mechanical	Water (salt air)
	Termites attack	78%	Chemical	Water & Sulphates
	Decay	62%	Biology	Micro-organisms
	Damaged	38%	Mechanical	Wind
Wall	Dampness	96%	Mechanical	Forces applied
	Mould	88%	Biology	Water
	Peeling paint	60%	Electromagnetic	Solar radiation
	Chalking	44%	Thermal	Climatic Cond.
	Decay	40%	Biology	Micro-organism
	Crack	20%	Mechanical	Forces applied
External Compound	Decay Column	24%	Biology	Micro-organism
	Erosion	22%	Mechanical	Forces applied
	Rusty grill	20%	Thermal/Chemical	Climate Cond.
	External wall crack	2%	Mechanical	Forces applied

The finding of qualitative survey on defects and agent causing factors for the building is shown in Table 4. Mechanical, chemical, and biological agents were the primary causes of faults in coastal residential buildings. According to the findings of a qualitative study, a high percentage (96%) of the elements experienced were rusty components, missing roofs, decay, and dampness conditions. Mould growth came in at the second-highest percentage (88%) after termite damage (82%) and was followed by peeling paint (60%) and chalking (44%) as well as damage (38%) and erosion (22%) and cracks (20%).

DISCUSSION AND ANALYSIS

For Building 1, the corrosion of louver windows and door hinges in buildings built near the seaside are subject to seawater intrusion. This is a result of the coastal area's wind direction and speed (salt air) affecting the building.

Meanwhile for Building 2, the corrosion of electrical equipment and door hinges is caused by the exposure of saltwater to electrical appliances in the building. This form of corrosion occurs when two different metals with physical or electrical contact are immersed in a common electrolyte (such as salt water) or when a metal is exposed to different concentrations of electrolyte. The seawater that condenses on building elements will finally evaporate, but the salt in the water will remain. This also results in the decay of the timber wall and its surface to be sticky.

Next, Building 3, is subject to seawater intrusion. The peeling of the paint due to dampness, sticky surface, and the corrosion of louvers windows are the symptoms that can be found in building 3. This is a result of the coastal area's wind direction and speed (salt air). The speed and the direction of the wind is determined by the weather of the area.

Rust on the metal component and decay of timber structure can be found in Building 4. In the coastal area, the quantity of moisture present in the air is higher than in the deserts. Hence, rusting of iron objects is faster. Biological damage to above-water parts of waterfront structures is caused directly or indirectly by the activity of fungi and insects that utilize wood for food or nesting material.

Epidemiologic evidence from primary studies and qualitative method analyses shows evidence of factors and main agents consistently associated to the defects found on the building at the Coastal Environmental. The examination of the data from the research study observational and qualitative methods reveals that there are essential parts that contributed to the building's defects. According to the type of defects that were discovered during the research study and data from the surveys, termite infestation, decay, rust, dampness, missing roofs, cracks, erosion, and mould growth were among the most common concerns at the buildings. Other building defects, such as chalking, honeycombing, and peeling paint occur often. Another defect found is the sticky condition on the walls surface. This is an uncommon defect as this defect only occur in coastal area buildings due the seawater intrusion. Both the observation and survey findings show similar defects found when analysing the data above.

CONCLUSION

The result interpretation has been laid down in this paper to confirm the contributing factors and main agents affecting building defects in the coastal environmental of Malaysia from a case study. The prevention offered coastal defect prevention to limit future difficulties of the defects were explore based on observation, and questionnaires. Defects found in the building coastal area come in a variety of agents and types as found by (Hanafi et al., 2018; Othuman Mydin et al., 2012) . Saltwater and strong wind are huge problems to the building nearby the sea (Mackenzie & Et al, 2018). The agents or consequences of moisture in the building will damage the element making a variety of defects forms such as rusty (Rodriguez, 2018), decay, sticky and mould growth. While, damaged windows, doors, and missing roof parts resulting from the agent of mechanical. However, to prevent any major issues in the future, building owners need to maintain their building safety and in fine condition. This study's findings suggest that building owners in the coastal area should consider materials that are stable against significant wind vibrations and can survive the reaction of the sea salt content. Furthermore, the building owner is responsible for doing routine maintenance at their building by performing planned maintenance. For instance, by doing monthly and yearly scheduled maintenance. As a result of its ability to inspect the building and monitor its performance, it may also contribute to reducing building defects.

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Surat kami : 700-KPK (PRP.UP.1/20/1)

Tarikh : 20 Januari 2023

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27.1.2023

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