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Research Article

Maintenance of National Heritage Anglican Churches in Malaysia

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This paper addresses the maintenance of National Heritage Anglican churches in Malaysia. A field survey is presented, describing the current defects of selected Anglican churches in Malaysia and proposing maintenance practices against the identified defects. The neglect in maintaining Anglican churches is alarming. The survey revealed that, aside from routine housekeeping, the majority of the churches surveyed had little to no regular maintenance. As the studied Anglican churches are Malaysian's National Heritage, the study adopted AHP and ANP to determine the relative importance of building discipline and space type inside a church, ensuring that the maintenance shall not neglect the values of these entities. Collectively, the in-situ survey results, the maintenance practices recommended by past literature, and the relative importance of building discipline and space type were used to propose a maintenance plan. Instead of generalising areas inside a church, different areas within a church are weighted differently in terms of importance levels, especially due to the fact that churches have a substantially different occupancy rate than conventional buildings. With the proposed hierarchy, priority might be given to the most vital areas first. In addition, church assets differ from those of other types of buildings, and their features should not be addressed in the same way. The research gives an improved asset hierarchy for churches based on the findings of multicriteria decision-making analysis. With this hierarchy in place, building custodians or maintenance personnel may find it easier to prioritise maintenance activities at churches, especially when financial is often limited.

1. Introduction

Malaysia is one of the nations with a wide range of architectural styles and historic structures that contribute to the country's character. It has significant roots in both historical and cultural influences due to its multicultural and culturally diverse community [1]. Places of worship play a central part in the spiritual and family lives of many people and have done so for generations. Places of worship should be well-maintained in the perspective of tourism economics. According to David [2], more efforts should be made to protect prominent houses of worship because they are major tourist destinations. Failure to preserve these locations might have a severe impact on a country's revenue, according to Malaysia's Tourism and Culture Deputy Minister, Datuk Mas Ermieyati Samsudin [3]. Visitors enjoy these places of worship because they have their own historical, cultural, and aesthetic aspects, as well as unique architecture.

Although many of these prominent places of worship have been officially listed as National Heritage Building in Malaysia, Idrus et al. [4] highlighted that many heritage buildings still remained in poor conditions with signs of serious building defects. These defects threaten their survival because legislations related to heritage buildings in the country do not sufficiently address the issue of maintenance and its management in the maintenance of heritage buildings, therefore, eventually lead to deterioration. According to a pilot survey conducted by Kamal et al. [5] on the maintenance of historic buildings in Malaysia, the result regrettably showed that 39% of the surveyed historic buildings was in poor conditions, with a more saddening

74% of which had not been maintained properly. Out of these surveyed historic buildings, places of worship stood majority consisted of 83%. These places of worships have shown observable signs of building defects. This issue becomes even more crucial when these buildings were mainly built with timber [6]. Unlike reinforced concrete, timber still undergoes carbon cycle, thus, is more vulnerable to parasites. Local news media too reported that the maintenance for the State Mosque of Selangor remained unsatisfactory [7]. The Auditor-General's Report revealed that seven forms of damages experienced by the Sultan Salahuddin Abdul Aziz Shah Mosque had been neglected.

From the past literature, it is found that the consideration for places of worship is indeed lacking and requiring specific care and attention. Seeing that most places of worship in Malaysia, even listed as National Heritage, are still in unsatisfactory conditions, it leads to the necessity to first assess these places of worship. The first step to effectively conduct a field assessment is to identify the assets of the facilities. However, as argued by Eweda et al. [8], generic field assessment assumed the spaces in a building were equally important. Without prioritisation, the maintenance effort will be less organised and less effective, especially when maintenance is being focused on spaces that are less important than the others [9]. Prioritisation is necessary in the development of the maintenance plan.

2. Background of Anglican Churches in Malaysia

The presence of Christianity in Malaysia can be traced back to as early as 650–660 CE, first introduced by the Nestorians. Not until around the end of the fifteenth century, however, Malaysia had had three visits from three different groups of Western Christians, namely Portuguese Reconquista Catholicism (1511–1641), Dutch Protestantism (1641–1824), and English Anglicanism (1786–1957) [10]. Unlike the peaceful merchants of Nestorian Christianity, Reconquista Catholicism had brought violence, despite having built eighteen churches and one Cathedral in Malay Peninsula.

After 130 years of being a Portuguese colony, Reconquista Catholicism was brutally replaced by Dutch Protestantism in 1641 when the Dutch East India Company assaulted and wrested Malacca from the Portuguese. It was in this 183 year of colonisation, and the Catholicism churches had been savaged by the Dutch.

Anglicanism came to Malaysia following the Union Jack in 1786 [10]. During the period of British-Malaya, Anglican churches had been constructed by the British for their chaplains who were mainly in Penang, Melaka, and Singapore. Following the purpose built of St George's Church in Penang in 1818, the horizons of the church extended gradually in other places in Malay Peninsula. It was also during this period, the Dutch Reformed buildings, including the prominent Christ Church, was replaced by the British to provide Anglican facilities for worship in Melaka [11].

The episcopal supervision for the chaplaincy work on Penang, including the St George's Church, was initially relied on the Diocese of Calcutta. As the supervisory responsibility became heavier when the diocese extended from India to New Zealand, a Diocese of Singapore, Labuan and Sarawak were formed for a better administration of churches in Malay Peninsula [12]. The diocese was later reorganised into Diocese of Singapore and Diocese of Borneo in 1909, subsequently becoming the Diocese of Singapore and Malaya after Malaya gained her independence from the British in 1957. Today, Anglican churches in Malaysia are under the provisions of Diocese of West Malaysia, a new and independent diocese formed in 1970. The Anglican Communion has become the third largest Christian denomination in the world, after Roman Catholicism and Eastern Orthodoxy [13].

Since Anglican churches in Malaysia were mostly constructed by colonisers within the period of 446 years, they were typically designed in the colonial architecture. Colonial architecture is generally characterised by a result of cross-cultural elements not only with the local Malay built environment but including the influences from Islamic, Chinese, and Indian cultures and architectural styles [14]. The hybrid of diverse architectural backgrounds incorporating the East and the West, thus, produces a new architectural style. Examples can be seen from the overhanging roofs, large window openings, and cantilever veranda. According to Pyszka [15], the spreading of reformation ideas throughout Europe and England over the 200 years had significantly changed the religious practices and material culture of Anglican churches, most noticeably in their design and interior furnishings. The removal of some features from the churches includes the elaborate painted murals, statues of saints, stained glass windows, and chancel screens that separated priests from their parishioners. Reflecting Protestant ideology, priests and parishioners were instead sharing a common space with far less-elaborated interior decorations.

3. Methodology

The methodological triangulation used in proposing the maintenance is schematically illustrated in Figure 1. Methodological triangulation, more commonly referred to in the literature as mixed-method research, is the use of at least two methods, usually qualitative and quantitative, in a single study [16–18]. The reason behind combining two or more methods in a study is due to the inadequacy of a single method. Methodological triangulation is used, therefore, to ensure that the most comprehensive approach is taken to tackle the research problems [17].

According to Morse [17], the essential step for methodological triangulation is to determine whether the research problem is principally qualitative or quantitative. Difference among characteristics of the research problem leads to different paths of design for researches. In this research, the first characteristic of the research problems had been identified from literature review. Due to the conspicuous lack of theory and previous research, the concept and even discussions about the maintenance of places of worship are rather limited [19]. However, the practical problem observed the need for exploration and

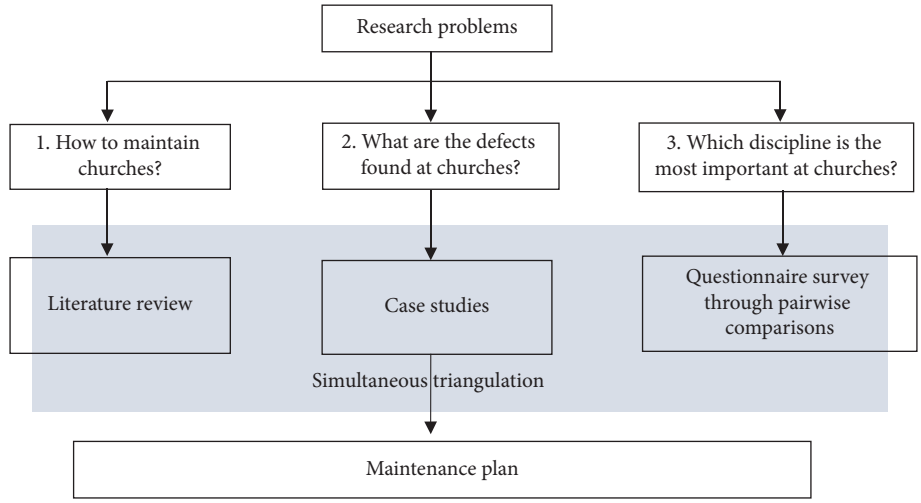

Figure 1: Methodology used to propose maintenance plan for Anglican churches in Malaysia.

measurements to remedy the situation, where many of these places of worship remained in poor conditions, some even with serious signs of defects [4, 5, 7]. It prompted the need to explore and describe the phenomena and to subsequently develop a theory. The author also noted that there might be a notion of existing theories, such as generalised BCA, and the space-based condition assessment model that Eweda et al. [8] proposed may be inadequate to address the maintenance issues, specifically at places of worship due to their uniqueness. Although the inadequacy would be further elaborated in the following quantitative section, these reasons had sufficiently fulfilled the characteristics of a qualitative research problem articulated by Morse [17].

There are two classifications of methodological triangulation: simultaneous and sequential [16, 17]. These categories refer to the difference in the chronological order used between methods. Morse [17] elaborated, in simultaneous triangulation, qualitative and quantitative methods are used at the same time to solve research problems. This means there is a minimal interaction between methods and datasets during the data collection, but eventual findings complement one another to produce a combined answer. Sequential triangulation, on the other hand, is used when the results of one method are essential for conducting the next method. In this approach, it could be either using qualitative results to explain quantitative data, or using quantitative tests results to improve results from qualitative research [20]. To decide the most suitable approaches, Morse [17] emphasised to determine whether the theory that drove the research was developed inductively from the research per se or used deductively as in quantitative inquiry. The outcomes of this differentiation are several types of methodological triangulation.

For this paper, the notation QUAL + quan was used, which indicated simultaneous triangulation [17]. The research problem was clearly a qualitative problem, and grounded theory might be used to describe the features and maintenance issues. From the field assessment reports, the author could therefore observe the defects and propose maintenance practices to either prevent or remedy such defects, or both. However, as observed from literature, the assets of churches were rather unique and differed from other types of building [21–23]. This led to the next question: which parts are more important to maintain first? Clearly, the maintenance practices would become more efficient if resources could be prioritised according to their importance levels.

3.1. Literature Review. This paper adopted pragmatism as the philosophical idea largely due to the problem-centred nature of the research. From the observed practical problem, it elevated to a research question worth asking: how to maintain churches? Rather than focusing on theories, the ultimate aim of this research targeted on real-world practices and techniques on maintaining valuable churches. "Many places of worship remained in poor conditions" was a situation deemed problematic. It was an issue that the researcher aimed to solve or improve. In order to understand the situation, it was crucial to first answer "what was neglected?," thus leading to the necessity to first identify the features of churches.

Literature review is the comprehensive interpretation and study of literature that relates to a particular topic [24]. Conventionally, there are three sources of literature review: primary, secondary, and tertiary [25]. While primary sources mean "raw data" collected by other researchers and published in their reports, secondary sources typically review on other researchers' works. Tertiary sources are books and articles that synthesise and index on secondary sources for general readers, commonly presented as bibliographies, encyclopaedias, and mass-circulation publications. Mainly gathered from primary and secondary sources of literature-academic journal articles, technical papers, textbooks, and reports, the maintenance practices were compiled from past literature.

3.2. Case Studies. After reviewing the literature and obtaining information about the features and potential maintenance practices on churches, the research reached at a point whereby finding out the condition of real-world

churches in Malaysia become crucial. The motive here was to answer the question "what are defects that could be found at these churches?." The key to the selection of methods was the "what," as it implied a more explanatory nature. Indeed, explanatory researches are more likely to lead to the use of case studies as preferred research method [26, 27].

Case studies are a design of inquiry, especially evaluation, found in various fields in which the researcher develops an in-depth analysis of a case [20]. Especially when the proposed research addresses a contemporary phenomenon in which the researcher has no control over, case study is deemed a more suitable method to provide a dynamic data.

In the context of this paper, the building condition assessment developed by JKR [28] was the data collection procedure adopted to collect detailed information about the conditions of selected churches. The collected information is the building portfolio, such as building age, floor area, and the defects of its components from three main disciplines (Architecture & Civil, Electrical, and Mechanical), categorised by JKR [28].

3.3. Analytic Hierarchy Process (AHP). Developed by Saaty, analytic hierarchy process (AHP) is a multicriteria theory of measurement used to derive relative priority scales from individual judgements [29]. It is typically conducted through pairwise comparisons, which contain a set of scale of absolute judgements that denotes how one element dominates one another with respect to a given attribute. According to Saaty [30], the logic behind AHP is to systematically break down unstructured and complex situations into smaller, organisable components, have these components arranged hierarchically, and assign eigen values based on subjective judgements. Based on these values, decision-makers could then determine the relative weights of each component, and actions could, therefore, be more efficiently executed following the identified priorities. AHP has become one of the most widely used multicriteria decision-making tools [31]. Due to its flexibility, not only many outstanding works have been published involving its applications in planning, alternative selections, resource allocations, and optimisation but also the integration of AHP with other techniques such as fuzzy logic, linear programming, and quality function development. These convergences of techniques often provide a better and more accurate result [32].

In this paper, AHP had been adopted to rank the spaces inside a church to determine the relative weight of each space in a building. Spaces in a church are determined vertically by walls, and horizontally by floor and ceiling. However, unlike most types of building where "spaces" are normally separated by walls as "rooms," spaces considered in the case of a church are not separated by such walls. However, they follow, and as adopted from the literature review, the schematic plan of a church typically contains: (1) narthex, (2) nave, (3) crossing, (4) transept, and (5) chancel (choir & sanctuary). According to Eweda et al. [8], different space types have different requirements and characteristics. This triggers the differences in relative importance between one space and another based on many factors, even in a specific building type. These factors include the function of the space, the occupancy rates, and the duration and frequency of usage. For instance, the occupancy rate at chancel is supposedly much lower when compared to narthex; visitors at a church are normally restrained from entering the chancel.

3.4. Analytic Network Process (ANP). Built upon the foundation of the seven pillars of the analytic hierarchy process (AHP), however, ANP provides a general framework that allows for more complex, interdependent, feedback, and relationships among elements in the hierarchy; in a nonlinear structure without the need to specify levels as in a hierarchy [29, 32], ANP is generally referred to as the generic form of AHP.

In the past decades, ANP has increasingly been applauded among researchers as a useful tool in decision making, especially in the study of uncertainty and risk. Specifically, in the research conducted by Sipahi and Timor [32], from a collection of more than 600 related and reputed papers published in the period of 2005–2009, they observed that the application of AHP and ANP had continued to increase exponentially, with the expectation that ANP would gain even more popularity as its benefits had become better understood. The applications of these techniques have been massive, covering various fields including but not limited to, manufacturing, environmental management, power and energy, construction, logistics, education, healthcare, banking and finance, marketing, auditing, and even archaeology [32].

According to [30], ANP is a connection of two parts. The first is being a control hierarchy or network of criteria, with interactions controlled by the subcriteria. The second is a network of influences among the clusters and elements. The network varies from criterion to criterion, and for each control criterion, a different supermatrix of limiting influence is computed. Lastly, each of these supermatrices is weighted by the priority of its control criterion and the addition for all the control criterion synthesise the results.

The presence of complex relationships between different building disciplines has been acknowledged in several past researches [33, 34]. Although efforts could be found in trying to explain the complexity and determine the relative weights of each discipline throughout the building hierarchy, Eweda et al. [8] pointed out that the examination on the relative weights of these disciplines within a space, and how they are changed from one space type to another, has slipped away. For example, the relative weight of audio-visual at chancel is different from its relative weight at spaces such as nave or narthex. Thus, a study on the relative weights of each discipline inside each particular space in a church is called-for, by using ANP.

ANP was chosen for this part of the research, particularly due to its speciality in addressing the interrelationships between different components, and the effect of deterioration from one component to the others'. In order to calculate the relative weights of each discipline, the disciplines and their respective families had been clustered, as shown in Figure 2. The flow of influence between the elements is indicated by the connections between the clusters.

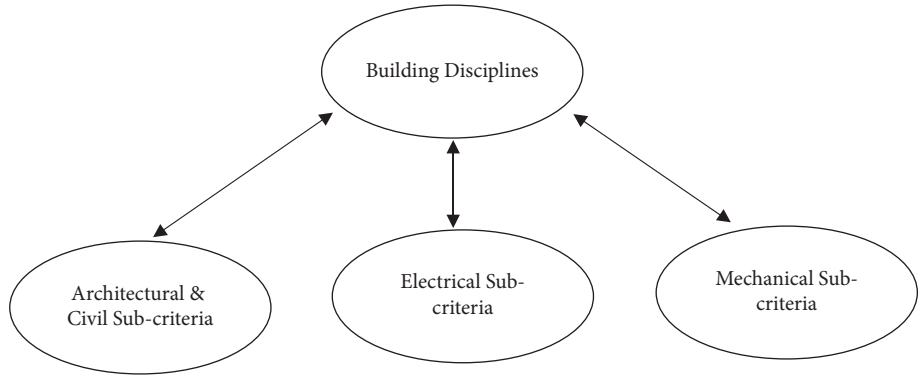

Figure 2: The network of influences between building categories and their families.

3.5. Sampling Technique. Conducting questionnaire survey naturally requires the researcher to select one or more samples to collect data from. Although in some specific cases where it is possible to conduct a census, which is to collect and analyse data from the entire population, a census is more often than usual unpractical due to time and budget constraints [35]. Moreover, a census might even be inappropriate to answering certain research questions, especially within business and management research. Careful considerations on the selections of sampling techniques, thus, become essential before conducting any survey to avoid targeting at the wrong audiences.

Sampling techniques are often categorised into two types: probability or representative sampling and nonprobability sampling [20, 35, 36]. Probability sampling is often connected to general survey and experiment research strategies. These kinds of researches usually involve statistical estimations on the characteristics of the target population from the sample. On the other hand, the probability of each sample being selected from the target population in nonprobability sampling is not acknowledged. The decision on which technique to be used is heavily dictated by the research questions and objectives of the research [35].

Nonprobability sampling technique, more specifically, the homogeneous sampling, had been adopted due to the nature and strategies employed in this research. Homogeneous sampling falls under the purposive or judgemental sampling group [35]. It is a technique that targets on one particular subgroup in which all the sample members are sharing specific similarities, such as age, gender, and occupation in an organisation's hierarchy. The logical ground behind selecting homogeneous sampling as the technique for this questionnaire survey was because the objectives of the research did not permit large-scale social surveys. Targeting a large-scale population without proper knowledge and professional experiences in the studied field, facilities management, would only generate unnecessary noises, giving inappropriate data for the purposes of the research.

This research targeted the "experts" in facilities management, in order to seek for their professional opinions regarding the importance of each space inside a church, as well as the importance of each discipline inside each space type. These "experts" were determined primarily by their job titles and length of experience in facilities management, majorly consisted of architects, facilities managers, conservators, and asset management consultants. However, as DeSimone [37] pointed out, although researchers wished that respondents could provide selfless responses to survey questions, it was common that participants had a tendency to agree or disagree with items, regardless of content, or struggled to present themselves in an aberrant or socially desirable manner. Since the presence of such data would be perplexing to the researcher, data screening had been applied in this research. Data screening method had been conducted through the first part of the same piece of questionnaire handed to the participants. This part of questionnaire required the respondents to fill up their particulars, such as job title, length of experience, and higher academic qualification. Respondents who did not pass the screening questions, for instance, being relatively new to the industry, would be omitted during the data cleaning process. The definition of "experts" in this research required the respondents to pass at least 4 out of 5 questions contained in Part 1: respondent's particular. The requirements to pass are tabulated in Table 1.

Since the target audience of questionnaire survey in this research was very specific, the true population was unknown. According to Uakarn et al. [38], when population was unknown but population proportion could be estimated, Cochran's formula could be adopted to calculate the sample size required for research. Cochran's formula was a sample size formula for categorical data developed by Cochran in 1977 [39]. The equation for Cochran's formula is shown as follows:

$$n = \frac{Z^2 p(1-p)}{e^2}, \tag{1}$$

where n is the sample size, Z is the value at reliability level or significance level, p is the population proportion, and e is the acceptable sampling error. Cochran [40] stated that the confidence level for most researches usually fell between 90% 99%. Based on the Z-score table, a confidence level of 95% reflected a Z-score of 1.96. The population proportion for the specific purpose of the research was estimated at 5%, considering the limited amount of literature review, as well as the extremely low awareness in maintenance for churches in Malaysia. The common acceptable sampling error was set at 5% (0.05). The calculation for sample size for this research is shown as follows:

Table 1: Requirements to pass the screening questions.

No	Question	Pass	Fail
1.1	Job title	Any from the selection	Others
1.2	Length of experience	≥5 years	<5 years
1.3	Education background	Any from the selection	Others
1.4	Highest academic qualification	≥Diploma	<Diploma
1.5	Number of maintenance projects involved	≥5	<5

$$n = \frac{1.96^2\,(0.05)\,(1-0.05)}{(0.05)^2} \approx 73. \quad (2)$$

Since the sample size was calculated and the result was 73, a total number of 73 questionnaires had been distributed solely through the internet by emails. These respondents were snowballed by first directing at the right respondents, and they were asked to forward the email to their peers in construction industry, including but not limited to consultants, engineers, conservators, architects, and facilities management leaders and members. The received responses were 38, resulting a 52% of response rate. A response rate of higher than 50% was deemed reasonable according to Saunders et al. [35], especially considering that the questionnaires were distributed using only one medium. Out of the 38 questionnaires received, 6 respondents had failed in the screening questions and, thus, had been omitted before data analysis.

4. Maintenance Practices for Anglican Churches in Malaysia

Churches generally share similarities regardless of denominations. While the interior design and furnishings of Catholic churches could be sophisticated, Anglican churches can be similar in appearance to Catholic churches [41]. Both churches are often in the shape of a cross, with a sanctuary at the east end. However, compared to Catholic churches, Anglican churches are often a lot plainer and have fewer candles and statues.

One of the most noticeable architectural characteristics of churches is that the religious heritage is mainly signified by a longitudinal plan, with a long nave eventually crossed by a transept [42]. The body of the building is a long, central portion of a hall arranged in naves as shown in Figure 3. The interior of naves often reaches its fullest height. The main nave is flanked on either side by lower aisles, with rows of piers or columns separating them. The main nave can end with a circular or polygonal apse.

From identifying the schematic plan and typical features for Anglican churches in Malaysia, the research proceeded with proposing the maintenance practices against potential defects found at these churches based on past literature. The findings are presented in Table 2.

5. National Heritage Anglican Churches in Malaysia Survey

To conduct the case studies, the researcher had visited the selected 4 churches in Malaysia in person, in order to obtain all necessary information. These pieces of information are

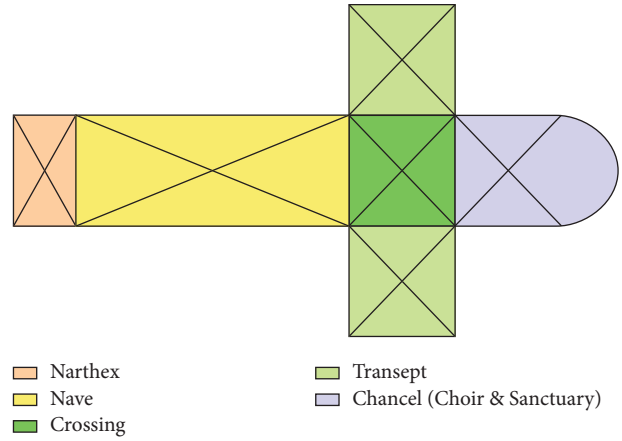

Figure 3: Schematic plan of an Anglican church in Malaysia.

then compiled and presented, respectively, in the following sections, in alphabetic order:

(i) All Saints' Church, Taiping

(ii) Christ Church Melaka, Melaka

(iii) St. George's Church, Penang

(iv) St. Mary's Cathedral, Kuala Lumpur

To neatly present the collected data, a building portfolio and a brief history of the church are provided to each of the studied cases (see Table 3). It is followed by the field survey (see Table 4) that was partly adopted from JKR's building condition assessment and segmented according to each building disciplines.

Case studies revealed that there were indeed some commonalities in their features among the churches surveyed. While being similar, each church possessed different kinds of defect. St. George's Church was the only one of these churches that received consistent support from Jabatan Warisan Negara (literally, Department of National Heritage). As a result, apparently, the condition of St. George's Church was the finest of them all, and the restorations works done on it could serve as a role model for other churches. Timber and brick were the most commonly used materials in the structure of these churches. While timber was employed entirely in the construction of All Saints' Church, it was more typically utilised in roof trusses for other churches. Timber-built All Saints' Church had, in fact, deteriorated more quickly than other brick-built churches. Many parts of its structure were discovered to be severely decayed. Worse, many of these flaws had gone unattended, resulting in a worrying state. The structures of brick-built churches were typically in better condition than those of timber churches.

Table 2: Proposed maintenance guideline for Anglican churches in Malaysia.

System	Subsystem	Material	Potential defects	Proposed maintenance	Inspection frequency	References
Architectural & civil						
Structure	Floor	Timber	Stain	Solvents to thin oil varnishes to achieve brush-able viscosity	Monthly	[43]
			Termite attack	Antitermite treatment by spraying, injecting, or fogging	Every three months	[44–46]
			Fungi attack	Organic fungicides treatment. Concentration of preservative required depending on the severity of fungicidal penetration	Every three months	[45–47]
			Minor defects (loose knots, deep shakes, deep cracks)	Filing of cavities and other spaces in damaged wood with putties, solid foams, or fillers	Monthly	[47]
			Severe damage	Minimise the amount of timber being replaced. Prosthesisation by selecting closest material to the original timber, and similar moisture content of the replacement timber	Every three months	[48]
		Marble	Stain	Dewaxing/waxing operation. Polishing & buffing	Every four years, every twenty years	[49]
		Ceramic	Stain	Ordinary cleaning	Ordinarily	[49]
		Carpet	Stain	Spray application with detergent, followed by a removal of the mixture through aspiration	Yearly	[49]
			Worn-out	Relaying	Every five years	[49]
	Column	Timber	Stain	Solvents to thin oil vanishes to achieve brush-able viscosity	Monthly	[43]
			Termite attack	Antitermite treatment by spraying, injecting, or fogging	Every three months	[44–46]
			Fungi attack	Organic fungicide treatment. Concentration of preservative required depending on the severity of fungicidal penetration	Every three months	[45–47]
			Minor defects (loose knots, deep shakes, deep cracks)	Filing of cavities and other spaces in damaged wood with putties, solid foams, or fillers	Monthly	[47]
			Cracks and rupture	Metallic reinforcement with self-tapping screws or steel plates	Every three months	[48, 50, 51]
		Masonry	Minor cracks	Grouting by injecting grout through ports into the columns use only nonchloride and noncorrosive ingredients to mix grout avoid cement	Monthly	[52–55]
			Cracks	Stainless steel rebars to be embedded into the column for severe buckled column	Monthly	[52]
			Water ingress	Repair leaks and ensure surface to dry replace bricks by reproducing new bricks to look like old ones. Use test panels to ensure similarity between old and new bricks. Ensure the strength of new bricks to be the same with old ones. Avoid causing damage to adjacent brickworks while removing and replacing. Use reclaimed bricks whenever possible	Monthly	[56, 57]
			Efflorescence	Remove by dry-brushing and flushing with clean water. Use a very light sandblasting to remove more persistent efflorescence. Use dilute solution of muriatic acid (5%–10%) to remove harder efflorescence, solution should be more dilute (2%) for integrally coloured masonry. Test solution on small and unnoticeable portion to ensure adverse effect. Always keep the surface wet to avoid absorption of acid. Scouring the efflorescence with stiff bristle brush, avoid wire brush. Use high pressure water jet in the presence of calcium carbonate efflorescence	Monthly	[58]
			Erosion of lime mortar	Face grouting by filling small "hairline" cracks on brick surface. Reporting, or tuckpointing cracked, unbonded, or deteriorated mortar joints by removing damaged mortar and refilling new mortar. Duplicate the constituents and proportions of the original mortar	Monthly	[57, 59]

Table 2: Continued.

System	Subsystem	Material	Potential defects	Proposed maintenance	Inspection frequency	References
Exterior enclosure	Wall & painting	Timber	Shall be treated similarly to the maintenance of other structures			
		Masonry	Shall be treated similarly to the maintenance of other structures			
		Paint	Minor defects (cracking, chalking, weathering, rust spots or bleed-through from nail heads)	Routine inspection by damping paint surface with a damp rag or sponge, apparent changes of paint colour show the protective finish or the paint is gone. Repainting. Recoating to the exterior paint	Every five years	[60]
			Severe damage	Total replacement if damage	Every five years	[61]
	Window	Timber (sash)	Minor defects (difficulty in opening/closing sashes, broken pulleys or chords, stretched cords, overweight sashes, hardened putty)	Reconditioning using raw linseed oil or Stockholm tar. Remove sashes from frame with extra care. Balancing and easing by accessing the weight pocket located at the bottom of the pulley site. Replace broken or stretched cords using nonstretch cord of hemp or cotton. Replace new chains if necessary. Remove hardened putty by softening it using hot air gun or infrared lamps. Clean the window before reapplying putty	Every three months	[61–63]
		Metal (sash)	Severe damage	Total replacement if damage	Every five years	[61]
			Minor defects (blistering paint, lifting putty, distorting surface, corrosion)	Paint sealing on parts exposed to moisture attacks	Every three months	[63]
		Stained or leaded glasses	Buckling of the leadwork, cracking of individual panes, failure or cracking of joints	Shall only be conducted by certified conservator or specialist	Every three months	[62]
		Wooden	Shall be treated similarly to the maintenance of other structures			
	Door	Bronze	Deteriorated lacquer	Bronze surfaces should be cleaned thoroughly with mild soap and soft cloth. Apply lacquer remover on soft cloth. Wiping along the grain of the metal, and leaving it on for several minutes. Repeat application if necessary. At least twice ordinary washing with standard solvent after removal. Reapply lacquer within 4 hours of cleaning. Avoid application in inclement weather or when relative humidity is above 60%. Reapplied surface should be left untouched for 48 hours of drying time	Yearly	[63, 64]
			Stain	Solvents to thin oil varnishes to achieve brush-able viscosity	Monthly	[43]
			Termite attack	Antitermite treatment by spraying, injecting, or fogging	Every three months	[44–46]
			Fungi attack	Organic fungicides treatment. Concentration of preservative required depending on the severity of fungicidal penetration	Every three months	[45–47]
	Ceiling & roof	Hammer-beam roof	Minor defects (loose knots, deep shakes, deep cracks)	Filing of cavities and other spaces in damaged wood with putties, solid foams, fillers, or epoxy resins	Every three months	[47]
			Structural failures (bowing, splits)	Compact lift is suggested for accessibility. Install inexpensive indicators on-going monitor of structural movement such as built-in meters to detect fungal growth, and spy holes for fibre-optic inspection prosthesisation by selecting closest material to the original timber, and similar moisture content of the replacement timber to avoid moisture movement reinforcement using steel flitch plate at hidden members	Every six months	[65]
Electrical						
Lighting	Luminary	Floodlights, spotlights, light bulbs	Burned out, damaged fixtures	Group lamp replacement over individual replacement special connector that will set off the luminaries and allow quicker replacement replace old light bulbs with LEDs	Yearly	[66–69]
Audio-visual	Electronic devices	Projectors, projection screens, audio amplifiers, microphones, monitors, sound desks	System failure or defective	Test tone sweeps to be carried out on individual components specific routine cleaning on sensitive parts of these devices, such as optics in projection systems and cameras using professionally manufactured cleaning kits routine inspection on projector bulbs	Monthly	[70]
	Cabling	MICC, MICS	Cracks, pops, and failures caused by polarity and grounding	Cable tester to inspect cabling replace defective cables immediately to prevent damage to expensive PA systems	Yearly	[70]
	Cabling	MICC, MICS	Damage	Cable tester to inspect cabling contact local certified technician	Yearly	[70]
Electrical wiring	Other exterior components	Steel conduit, high impact plastic conduit, plugs, electrical panels	Damage	Visual inspection on damages check corrosive damage on line clamps or earth clamps, if found, clean corrosion only with dry cloth, replace clamps if heavy corrosion inspection on fuse, meter, or distribution board and their remedial works shall only be handled by certified contractor or electrician	Yearly	[63, 71, 72]
Mechanical						
HVAC				Replace existing HVAC systems	Yearly	[73, 74]

Table 3: Building profiles of National Heritage Anglican churches in Malaysia.

Case study	1	2	3	4
Official name	All Saints' Church	Christ Church Melaka	St. George's Church	St. Mary's Cathedral
Location	Taiping, Perak	Melaka	George Town, Penang	Kuala Lumpur
Country	Malaysia	Malaysia	Malaysia	Malaysia
Completed	1886	1753	1819	1894
Area	162.64 m^2	325 m^2	636 m^2	338.75 m^2
Main building materials	Timber	Dutch brick and laterite	Brick and timber	Brick
Last recorded maintenance	—	—	2010	2012
Frequency of maintenance	—	Condition-based	Condition-based with yearly inspection	Condition-based

Table 4: Defects of surveyed Anglican churches according to their materials.

System	Subsystem	Material	Defects	C1	C2	C3	C4
Architectural & civil							
Structure	Floor	Timber	Stain				
			Termite attack				
			Fungi attack				
			Minor defects (loose knots, deep shakes, deep cracks)				
			Severe damage				
		Marble	Stain		●		
		Ceramic	Stain	✓			●
		Terrazzo	Stain			●	
		Carpet	Stain	●	●	○	●
			Worn-out	○	○	○	●
		Others	Stain		●		
	Column	Timber	Stain	●			
			Termite attack	✓			
			Fungi attack	○			
			Minor defects (loose knots, deep shakes, deep cracks)	●			
			Cracks and rupture	○			
		Masonry	Fungi attack		●	○	○
			Minor cracks		○	○	○
			Cracks		○	○	○
			Water ingress		○	✓	○
			Efflorescence		○	✓	○
			Erosion of lime mortar		○	○	○

Table 4: Continued.

System	Subsystem	Material	Defects	C1	C2	C3	C4
Exterior enclosure	Wall & painting	Timber	Stain	●			
			Termite attack	✓			
			Fungi attack	○			
			Minor defects (loose knots, deep shakes, deep cracks)	○			
			Severe damage	●			
		Masonry	Minor cracks		●	●	○
			Cracks		○	○	○
			Water ingress		○	✓	●
			Efflorescence		○	✓	○
			Erosion of lime mortar		○	○	○
		Paint	Minor defects (cracking, chalking, weathering, rust spots or bleed-through from nail heads)	●	●	○	●
			Severe damage	○		○	○
	Window	Timber (sash)	Minor defects (difficulty in opening/closing sashes, broken pulleys or chords, stretched cords, overweight sashes, hardened putty)	●		○	○
		Metal (sash)	Severe damage	○			
			Minor defects (blistering paint, lifting putty, distorting surface, corrosion)	●			
		Stained or leaded glasses	Buckling of the leadwork, cracking of individual panes, failure or cracking of joints	●	○		○
	Door	Timber	Stain	●	●	○	●
			Termite attack	✓	○	✓	○
			Fungi attack	○	○	○	○
			Minor defects (loose knots, deep shakes, deep cracks)	●	●	○	○
		Bronze	Severe damage	○	●	○	○
			Deteriorated lacquer				
	Ceiling & roof	Hammer-beam roof	Stain	●			○
			Termite attack	✓			○
			Fungi attack	○			○
			Minor defects (loose knots, deep shakes, deep cracks)	○			○
			Structural failures (bowing, splits)	○			○
System	Subsystem	Material	Potential defects	C1	C2	C3	C4
Electrical							
Lighting	Luminary	Floodlights, spotlights, light bulbs	Burned out, damaged fixtures	●	○	○	○
Audio-visual	Electronic devices	Projectors, projection screens, audio amplifiers, microphones, monitors, sound desks	System failure or defective	○	○		○
Electrical wiring	Cabling	MICC, MICS	Cracks, pops, and failures caused by polarity and grounding	○	○		○
	Cabling	MICC, MICS	Damage	○	○	○	○
	Other exterior components	Steel conduit, high impact plastic conduit, plugs, electrical panels	Damage	○	○	○	○
Temperature control	Fan	Ceiling fan	Loosened screws, lubricating, movements or shakes	○		○	○
		Wall-mounted fans	Loosened screws, lubricating, movements or shakes		○		
Security	CCTV	Video camera	Flickering, connection issues, bad footage quality		○		○
Mechanical							
HVAC	Air conditioning	Air conditioner	Operational defect		○	○	○

Legends: ○ no defect, ● unresolved defect, and ✓ resolved defect.

Table 5: Frequency of part two of the questionnaire.

Scale		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Value		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Frequency	2.1.1	0	0	0	0	0	1	0	0	0	1	12	5	1	5	3	2	2
	2.1.2	0	0	3	6	3	4	2	7	1	5	0	1	0	0	0	0	0
	2.1.3	0	0	0	0	0	0	2	2	4	2	5	4	3	2	2	5	1
	2.1.4	0	0	0	0	1	0	0	0	0	0	1	3	12	6	5	1	3
	2.1.5	2	6	7	2	8	4	1	2	0	0	0	0	0	0	0	0	0
	2.1.6	0	0	0	8	6	8	2	6	0	0	0	0	0	1	1	0	0
	2.1.7	0	0	0	3	5	4	3	7	2	3	1	0	1	1	2	0	0
	2.1.8	0	0	0	0	0	0	0	1	6	4	4	3	4	5	3	2	0
	2.1.9	0	0	0	0	0	0	0	0	0	0	0	0	6	8	8	10	0
	2.1.10	0	0	0	0	0	0	0	0	0	0	6	5	9	3	5	4	0

Table 6: Averaged value and corresponding scale for part two of the questionnaire.

Question	Averaged value	Scale
2.1.1	12.6	5
2.1.2	6.66	3
2.1.3	12	4
2.1.4	13.6	6
2.1.5	4.06	6
2.1.6	6.28	4
2.1.7	7.94	2
2.1.8	11.9	4
2.1.9	14.7	7
2.1.10	13.3	5

Table 7: The priorities of each space type inside a church.

Space type	Normalised by cluster	Limiting	Weighted rank
Narthex	0.06636	0.066356	4
Nave	0.30701	0.307005	2
Transept	0.03944	0.039439	5
Crossing	0.13558	0.135581	3
Chancel	0.45162	0.451618	1

6. Findings of Pairwise Comparison Expert Survey

A total number of 32 questionnaires, excluding the 6 omitted questionnaires that had failed the screening questions, had been analysed with the aid of software packages, namely SPSS and SuperDecisions. The questionnaire contained three parts: (1) respondent's particular, (2) the importance of each space type inside a church (AHP), and (3) the importance of each building discipline inside a church (ANP). The respondent's particular data were straightforward and had been analysed using SPSS, while the second and third parts of the questionnaire would require SuperDecisions for AHP and ANP analyses. However, as the software did not allow multiple inputs, the average of each response of the 32 questionnaires had been calculated prior to the data analysis. Once the average had been obtained, they were then inserted into SuperDecisions for pairwise comparison analysis.

6.1. Respondent's Demographic. Architects made up the bulk of the responders, accounting for 37.5 percent of the total. Both the maintenance manager and the asset/facility management consultant came in second with 21.9 percent of the total responses. Four conservators answered to the surveys, accounting for 12.5 percent of the total, while facility manager accounted for 6.3 percent of the total. There were two more respondents with other job titles, but both of them failed the screening questions and were thus excluded.

The majority of the respondents, 53.1 percent of the total, had 5 to 15 years of work experience. 6 respondents each said

Table 8: Weighted super matrix for part three (ANP) of the questionnaire.

	Architectural & civil	Electrical	Mechanical	Floor	Column	Wall & painting	Window	Door	Ceiling & roof	Lighting	Audio-visual	Ceiling fan	Electrical wiring	HVAC
Architectural & civil	0	0	0	0.625	0.7286	0.6608	0.7583	0.3325	0.6267	0.3522	0.0783	0.0953	0.1265	0.0924
Electrical	0	0	0	0.2385	0.1088	0.1311	0.0905	0.1397	0.2797	0.5591	0.7167	0.6548	0.687	0.4232
Mechanical	0	0	0	0.1365	0.1626	0.2081	0.1513	0.5278	0.0936	0.0888	0.2051	0.2499	0.1865	0.4844
Floor	0.0241	0.1038	0.0561	0	0	0	0	0	0	0	0	0	0	0
Column	0.2488	0.0609	0.0827	0	0	0	0	0	0	0	0	0	0	0
Wall & painting	0.0465	0.0987	0.0571	0	0	0	0	0	0	0	0	0	0	0
Window	0.2574	0.0636	0.0594	0	0	0	0	0	0	0	0	0	0	0
Door	0.0607	0.1176	0.1357	0	0	0	0	0	0	0	0	0	0	0
Ceiling & roof	0.113	0.3058	0.3595	0	0	0	0	0	0	0	0	0	0	0
Lighting	0.1113	0.0489	0.0107	0	0	0	0	0	0	0	0	0	0	0
Audio-visual	0.0193	0.0775	0.1136	0	0	0	0	0	0	0	0	0	0	0
Ceiling fan	0.0235	0.0166	0.036	0	0	0	0	0	0	0	0	0	0	0
Electrical wiring	0.0173	0.0285	0.0111	0	0	0	0	0	0	0	0	0	0	0
HVAC	0.0783	0.0783	0.0783	0	0	0	0	0	0	0	0	0	0	0

Table 9: The calculation of decomposed weight of building discipline inside a church.

Building discipline	Narthex			Nave			Transept			Crossing			Chancel		
	W (SP_i)	W (Dis_j)	W (Fam_k)	W (SP_i)	W (Dis_j)	W (Fam_k)	W (SP_i)	W (Dis_j)	W (Fam_k)	W (SP_i)	W (Dis_j)	W (Fam_k)	W (SP_i)	W (Dis_j)	W (Fam_k)
Architectural & civil	0.06636	0.52604	0.7505	0.30701	0.52604	0.7505	0.03944	0.52604	0.7505	0.13558	0.52604	0.7505	0.45162	0.52604	0.7505
Electrical	0.06636	0.26862	0.1715	0.30701	0.26862	0.1715	0.03944	0.26862	0.1715	0.13558	0.26862	0.1715	0.45162	0.26862	0.1715
Mechanical	0.06636	0.20534	0.0783	0.30701	0.20534	0.0783	0.03944	0.20534	0.0783	0.13558	0.20534	0.0783	0.45162	0.20534	0.0783

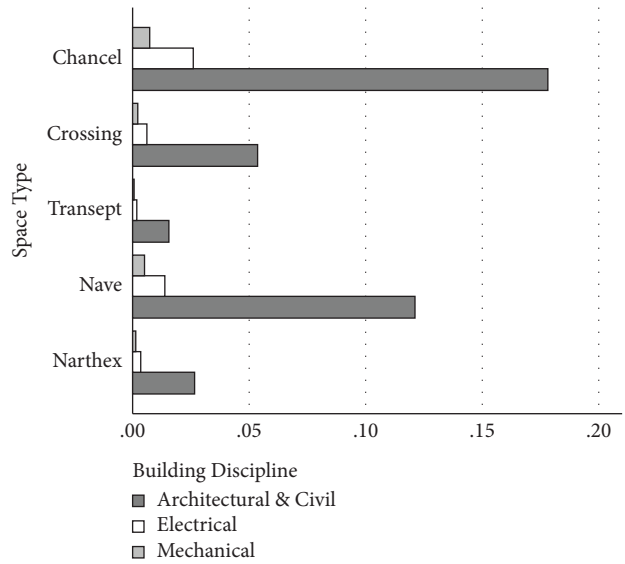

Figure 4: Decomposed weight of building discipline inside a church.

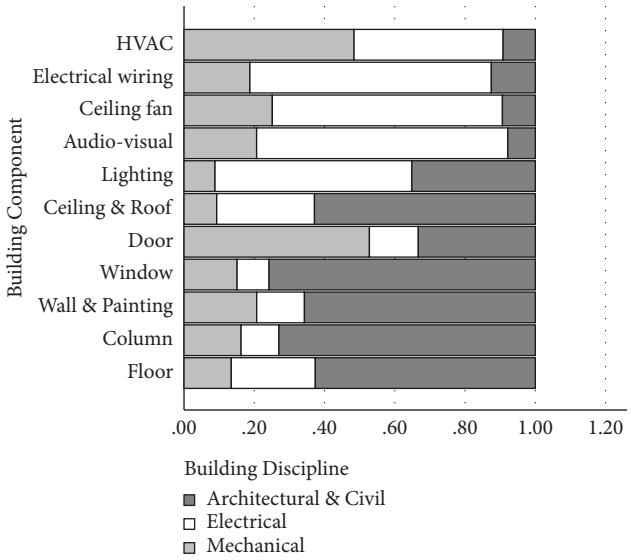

Figure 5: Comparison of building components with respect to each building discipline.

they had less than 5 years of work experience and more than 15 years of professional experience, each accounting for 18.8% of the total. The responders with the working experience ranges between 10 to 15 years were the fewest (3), accounting for just 9.4 percent of the total.

Most of the responders were architecture and engineering graduates. Architects made up 40.6 percent of the responders, while engineers added up 37.5 percent. Building surveyors made up the third highest percentage of responders, accounting for 9.4 percent of the total. The results show that two respondents, representing for 6.3 percent of the total, had a background in asset/facility management. The other two respondents, who also made-up 6.3 percent of the total, stated that they had completed a project management course.

A bachelor's degree was held by the majority of respondents, with 21 of them accounting for 65.6 percent of the total. A master's degree was held by 28.1 percent of the respondents. Only two of the respondents received a diploma, accounting for only 6.3% of the total. None of the respondents had earned a doctorate.

The majority of the projects in which the respondents are participating are in the range of 5 to 10 and 10 to 15 projects. While the group of 5 to 10 projects garnered the most responses, accounting for 43.8 percent of the total, twelve respondents had been associated with 10 to 15 projects thus far, accounting for 37.4 percent of the total. Four respondents were very new to the sector, having worked on fewer than five projects, accounting for 12.5 percent of the

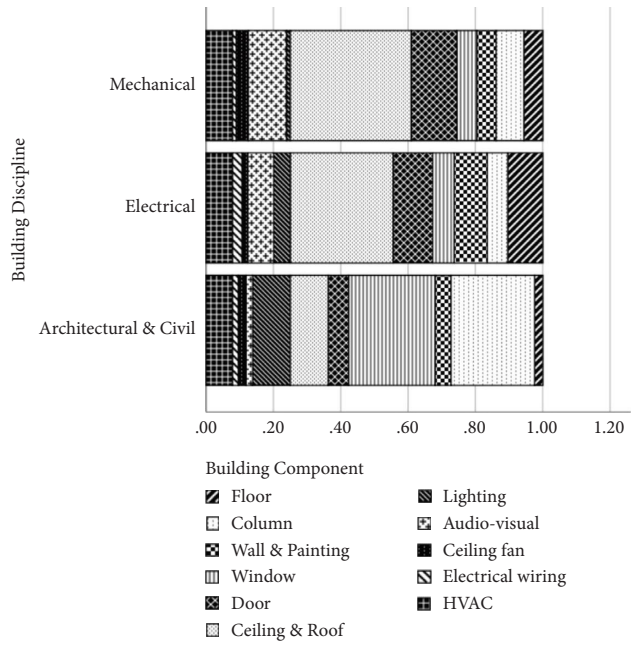

Figure 6: Comparison of building disciplines with respect to each building component.

total. Finally, two senior responders had worked on more than 15 projects, resulting 6.3 percent of the total.

6.2. The Importance of Each Space Type inside a Church (AHP). Table 5 presents the frequency of responses in part two of the questionnaires. To assess the relevance level, the average of 32 respondents' matrices for question 2.1 was calculated (see Table 6) and input into SuperDecisions for pairwise comparisons between each space inside a church. The relative weight of each space type is used to determine the priority level.

Table 7 depicts the importance of each space type within a church. With a normalised weight of 0.45162, the chancel was placed first as the most essential space type inside a church, according to the findings of the expert surveys. The normalised weight for nave, the second most significant space type within a church, is 0.30701. Crossing came in third place, with a normalised weight of 0.13558. The narthex and transept were placed fourth (0.06636) and fifth (0.03944), respectively, as the least two space types inside a church.

6.3. The Importance of Each Building Discipline inside a Church (AHP). Part three of the questionnaire contains more questions than part two due to the nature of interrelationships in ANP. Other than comparing the building components with each other with respect to each building discipline, the building disciplines had to be compared with each other, too, with respect to every building component.

Table 8 presents the weighted super matrix for part three (ANP) of the questionnaire, generated from SuperDecisions. The matrices, with respect to each building discipline by each building components, are shown in the table, representing the relative weight of each building component inside each building discipline. These values are important for the calculation of W (Fam_k), the relative weight of each family inside each building discipline in the following section.

7. Maintenance Plan for Anglican Churches in Malaysia

The inputs of literature review had been used to develop the maintenance practices for Anglican churches in Malaysia. The maintenance guideline had been subsequently used to survey the selected churches in Malaysia to identify the defects at these structures. However, as previously stated, due to the differences in asset for churches compared to ordinary structures, it has become necessary to determine the importance hierarchy for their features and building components, as well as between different building disciplines. Thus, the implement of multicriteria decision-making (MCDM), typically AHP and ANP analyses, had been conducted to determine the importance levels of building disciplines, along with their respective building components within a church.

In order to calculate the decomposed weight of building discipline inside a church, the equation, W (SP_i) $\times$ W (Dis_j) $\times$ W (Fam_k), is applied. The process of calculating the decomposed weight of building discipline inside a church is shown in Table 9, and the results are presented in the bar chart as shown in Figure 4. The bar chart depicts that the decomposed weight for architectural and civil is overall the highest and is also the highest at the chancel based on space type, due to chancel being the most important area inside a church. Subsequently, the decomposed weights for electrical and mechanical at chancel have also increased. Figure 5 shows the comparison of building components with

Table 10: Proposed maintenance plan for Anglican churches in Malaysia.

System	Subsystem	Material	Defects	Ch	Nv	Cr	Nx	Tr	Proposed maintenance	Inspection frequency
Architectural and civil										
Structure	Floor	Timber	Stain						Solvents to thin oil varnishes to achieve brush-able viscosity	Monthly
			Termite attack						Antitermite treatment (organic or inorganic) by spraying, injecting, or fogging	Every three months
			Fungi attack						Organic fungicides treatment. Concentration of preservative required depends on the severity of fungicidal penetration	Every three months
			Minor defects (loose knots, deep shakes, deep cracks)						Filing of cavities and other spaces in damaged wood with putties, solid foams, and fillers	Monthly
			Severe damage						Avoid harming the authenticity of the structures. Minimise the amount of timber being replaced. Adopt prosthesisation by selecting closest material to the original timber, and similar moisture content of the replacement timber to avoid moisture movement	Every three months
		Marble	Stain						Dewaxing/waxing operation	Every four years
									Polishing & buffing	Every twenty years
		Ceramic	Stain						Ordinary cleaning	Ordinarily
		Terrazzo	Stain						Polishing & buffing	Every twenty years
		Carpet	Stain						Spray application with detergent, followed by a removal of the mixture through aspiration	Yearly
			Worn-out						Relaying	Every five years
	Column	Timber	Stain						Solvents to thin oil varnishes to achieve brush-able viscosity	Monthly
			Termite attack						Antitermite treatment (organic or inorganic) by spraying, injecting, or fogging	Every three months
			Fungi attack						Organic fungicides treatment	Every three months
			Minor defects (loose knots, deep shakes, deep cracks)						Filing of cavities and other spaces in damaged wood with putties, solid foams, and fillers	Monthly
			Cracks and rupture						Metallic reinforcement with self-tapping screws and/or steel plates	Every three months
			Fungi attack						Organic fungicides treatment. Concentration of preservative required depends on the severity of fungicidal penetration	Every three months
		Masonry	Minor cracks						Grouting by injecting grout through ports into the columns	Monthly
			Cracks						Stainless steel rebars to be embedded into the columns for severe buckled column	Monthly
			Water ingress						Repair leaks and ensure surface to dry. Replace bricks by reproducing new bricks to look like old ones. Use test panels to ensure similarity between old and new bricks. Ensure the strength of new bricks to be same with the old ones. Avoid causing damage to adjacent brickworks while removing and replacing. Use reclaimed bricks whenever possible	Monthly
			Efflorescence						Most efflorescence can be removed by dry-brushing and flushing with clean water. Use a very light sandblasting to remove more persistent efflorescence. Use dilute solution of muriatic acid (5%–10%) to remove harder efflorescence, solution should be more dilute (2%) for integrally coloured masonry. Test solutions on small and unnoticeable portions to ensure adverse effect always keep the surface wet to avoid absorption of acid. Scouring the efflorescence with stiff bristle brush, avoid wire brush. Use high pressure water jet in the presence of calcium carbonate efflorescence	Monthly
			Erosion of lime mortar						Face grouting by filling small "hairline" cracks on brick surface. Reporting, or tuckpointing cracked, unbonded, or deteriorated mortar joints by removing damaged mortar and refilling new mortar. Duplicate the constituents and proportions of the original mortar	Monthly

Table 10: Continued.

System	Subsystem	Material	Defects	Ch	Nv	Cr	Nx	Tr	Proposed maintenance	Inspection frequency
Exterior enclosure	Wall & painting	Timber	Stain						Solvents to thin oil varnishes to achieve brush-able viscosity	Monthly
			Termite attack						Antitermite treatment (organic or inorganic) by spraying, injecting, or fogging	Every three months
			Fungi attack						Organic fungicides treatment. Concentration of preservative required depends on the severity of fungicidal penetration	Every three months
			Minor defects (loose knots, deep shakes, deep cracks)						Filing of cavities and other spaces in damaged wood with putties, solid foams, and fillers	Monthly
			Severe damage						Avoid harming the authenticity of the structures. Minimise the amount of timber being replaced. Adopt prosthesisation by selecting closest material to the original timber, and similar moisture content of the replacement timber to avoid moisture movement	Every three months
		Masonry	Minor cracks						Grouting by injecting grout through ports into the columns	Monthly
			Cracks						Stainless steel rebars to be embedded into the columns for severe buckled column	Monthly
			Water ingress						Repair leaks and ensures surface to dry. Replace bricks by reproducing new bricks to look like old ones. Use test panels to ensure similarity between old and new bricks. Ensure the strength of new bricks to be same with the old ones. Avoid causing damage to adjacent brickworks while removing and replacing. Use reclaimed bricks whenever possible	Monthly
			Efflorescence						Most efflorescence can be removed by dry-brushing and flushing with clean water. Use a very light sandblasting to remove more persistent efflorescence. Use dilute solution of muriatic acid (5%–10%) to remove harder efflorescence, and solution should be more dilute (2%) for integrally coloured masonry. Test solutions on small and unnoticeable portion to ensure adverse effect always keep the surface wet to avoid absorption of acid. Scouring the efflorescence with stiff bristle brush, avoid wire brush. Use high pressure water jet in the presence of calcium carbonate efflorescence	Monthly
			Erosion of lime mortar						Face grouting by filling small "hairline" cracks on brick surface. Reporting, or tuckpointing cracked, unbonded, or deteriorated mortar joints by removing damaged mortar and refilling new mortar. Duplicate the constituents and proportions of the original mortar	Monthly
		Paint	Minor defects (cracking, chalking, weathering, rust spots or bleed-through from nail heads)						Routine inspection by damping paint surface with a damp rag or sponge, apparent changes of paint colour show the protective finish of the paint is gone. Repainting where necessary. Recoating on the exterior paint	Every five years
			Severe damage						Total replacement if damage	Every five years
	Window	Timber (sash)	Minor defects (difficulty in opening/closing sashes, broken pulleys or chords, stretched cords, overweight sashes, hardened putty)						Reconditioning using raw linseed oil or Stockholm tar. Remove sashes from frame with extra care. Balancing and easing by accessing the weight pocket located at the bottom of the pulley site. Replace broken or stretched cords using nonstretch cord of hemp or cotton. Replace new chains if necessary. Remove hardened putty by softening it using hot air gun or infrared lamps. Clean the window before reapplying putty	Every three months
		Metal (sash)	Severe damage						Total replacement if damage	Every five years
			Minor defects (blistering paint, lifting putty, distorting surface, corrosion)						Paint sealing on parts exposed to moisture attacks	Every three months
		Stained or leaded glasses	Buckling of the leadwork, cracking of individual panes, failure or cracking of joints						Shall only be conducted by certified conservator or specialist	Every three months
	Door	Timber	Stain						Solvents to thin oil varnishes to achieve brush-able viscosity	Monthly
			Termite attack						Antitermite treatment (organic or inorganic) by spraying, injecting, or fogging	Every three months
			Fungi attack						Organic fungicides treatment. Concentration of preservative required depends on the severity of fungicidal penetration	Every three months
			Minor defects (loose knots, deep shakes, deep cracks)						Filing of cavities and other spaces in damaged wood with putties, solid foams, and fillers	Monthly
			Severe damage						Avoid harming the authenticity of the structures. Minimise the amount of timber being replaced. Adopt prosthesisation by selecting closest material to the original timber, and similar moisture content of the replacement timber to avoid moisture movement	Every three months
	Ceiling & roof	Bronze	Deteriorated lacquer						Bronze surfaces should be cleaned thoroughly with mild soap and soft cloth. Apply lacquer remover on soft cloth. Wiping along the grain of the metal, and leaving it on for several minutes. Repeat application if necessary. At least twice ordinary washing with standard solvent after removal. Reapply lacquer within 4 hours of cleaning. Avoid application in inclement weather or when relative humidity is above 60%. Reapplied surface should be left untouched for 48 hours of drying time	Yearly
		Hammer-beam roof	Stain						Solvents to thin oil varnishes to achieve brush-able viscosity	Monthly
			Termite attack						Antitermite treatment (organic or inorganic) by spraying, injecting, or fogging	Every three months
			Fungi attack						Organic fungicides treatment. Concentration of preservative required depends on the severity of fungicidal penetration	Every three months
			Minor defects (loose knots, deep shakes, deep cracks)						Filing of cavities and other spaces in damaged wood with putties, solid foams, and fillers	Every three months

Table 10: Continued.

System	Subsystem	Material	Defects	Ch	Nv	Cr	Nx	Tr	Proposed maintenance	Inspection frequency
			Structural failures (bowing, splits)						Compact lift is suggested for accessibility. Install inexpensive indicators on-going monitor of structural movement such as built-in meters to detect fungal growth, and spy holes for fibre-optic inspection. Adopt prosthesisation by selecting closest material to the original timber, and similar moisture content of the replacement timber to avoid moisture movement. Reinforcement using steel flitch plate at hidden members	Every six months
System	Subsystem	Material	Potential defects	Ch	Nv	Cr	Nx	Tr	Proposed maintenance	Inspection frequency
Electrical										
Lighting	Luminary	Floodlights, spotlights, light bulbs	Burned out, damaged fixtures						Group lamp replacement over individual replacement. Special connector that will set off the luminaries and allow quicker replacement. Replace old light bulbs with LEDs	Yearly
Audio-visual	Electronic devices	Projectors, projection screens, audio amplifiers, microphones, monitors, sound desks	System failure or defective						Test tone sweeps to be carried out on individual components. Specific routine cleaning on sensitive parts of these devices, such as optics in projection systems and cameras using professionally manufactured cleaning kits. Routine inspection on projector bulbs	Monthly
Electrical wiring	Cabling	MICC, MICS	Cracks, pops, and failures caused by polarity and grounding						Cable tester to inspect cabling. Replace defective cables immediately to prevent damage to expensive PA systems	Yearly
	Cabling	MICC, MICS	Damage						Replacement	Yearly
	Other exterior components	Steel conduit, high impact plastic conduit, plugs, electrical panels	Damage						Visual inspection on damages. Check corrosive damage on line clamps or earth clamps, if found, clean corrosion only with dry cloth, replace clamps if heavy corrosion. Inspection on SSO 13A, fuse, meter, or distribution board and their remedial works shall only be handled by certified contractor or electrician	Yearly
Temperature control	Fan	Ceiling fan	Loosened screws, lubricating, movements or shakes						Tightening back loosened screws with screwdriver, focusing on areas such as fan, ceiling plate. Apply lubrication at oil holes, and if necessary, avoid automotive motor oil or oils with detergent. Check manufacturer's manual for lubrication details. Routine inspection on fan movements or shakes. If movements or shakes are found, dissemble the blades from the fan and stack them on top of each other to check if blades are bent or misshapen	Yearly
		Wall-mounted fans	Loosened screws, lubricating, movements or shakes							
Mechanical										
HVAC	Air conditioning	Air conditioner	Operational defect						Replace existing HVAC systems with mini-split system (split unit AC)	Yearly

Notes: Ch–chancel, Nv–nave, Cr–crossing, Nx–narthex, Tr–transept.

Table 11: Proposed priority hierarchy of space type for maintenance at Anglican churches in Malaysia.

Space type	Rank
Chancel	1
Nave	2
Crossing	3
Narthex	4
Transept	5

Table 12: Proposed priority hierarchy of building components for maintenance at Anglican churches in Malaysia.

Building component	Rank
Architectural and civil	
+Window	1
Column	2
Ceiling and roof	3
Door	4
Wall and painting	5
Floor	6
Electrical	
Audio-visual	7
Lighting	8
Electrical wiring	9
Ceiling fan	10
Mechanical	
HVAC	11

respect to each building discipline based on the unweighted matrices generated from SuperDecisions. The comparison of building disciplines with regard to each building component inside a church is shown in Figure 6.

The findings of the AHP and ANP analyses were merged into the initial maintenance guideline, to create the proposed maintenance plan for Anglican churches in Malaysia. First, space types inside a church were added to the maintenance guideline, which were sorted from most to least important from left to right. By adopting the maintenance guideline for field survey at Anglican churches, reading from it provides several pieces of information includes (1) the material of the building component; (2) the type of defects appeared on the building component; (3) the location of the defect; and (4) proposed maintenance practices against the defect. Furthermore, as budget is often limited for the maintenance of Anglican churches, the proposed framework provides the priorities according to space types and building disciplines. The proposed maintenance plan for Anglican churches in Malaysia is presented in Tables 10–12.

8. Conclusions

This paper revolves around several key topics, and collectively, these topics interact and engage with each other to ultimately become the outcome–the maintenance framework. These key topics include asset management (AM),

building maintenance, Anglican churches, analytic network process (ANP), and analytic hierarchy process (AHP). Following a coherent flow, the research began with the investigation on the maintenance at places of worship. The findings of preliminary literature suggested that the condition of many places of worship in Malaysia were indeed worrying. This circumstance caused the research's practical problem to be identified. From the practical problem (defective places of worship in Malaysia), following pragmatism a research philosophical idea of emphasising onto the research problem and question by applying all available approaches to understand the problem, a research question, "how to maintain churches?," had been elevated. By asking the research question, more research problems had been arisen. This key concept for research problems is to better understand the research question. By asking "how to maintain churches," it raised more problems to be solved. These research problems are "what are the potential defects found at these churches?," and "what is the asset hierarchy for churches?."

The findings, in fact, by using the maintenance guidelines drafted based on literature review, offered a clear picture of the current state of these churches and their features, grouped by three main building disciplines. The aesthetics are always a major factor in maintaining National Heritage Church. Furthermore, because of their historical significance, they ought to be maintained in their original aesthetics, which has proven to be a challenge in their upkeep. Conservation, thus, has a significant impact on these maintenance practices. Take, for example, the role model, St. George's Church, the major maintenance conducted in 2010 involved wide activities of restoration. Unless beyond repair, the elements at the church were to be repaired and remained. Even if they were to be replaced, much works had to be done on analysing and choosing the identical materials. Major efforts had been spent on restoring them to their original states.

The quantitative technique used in this study is dedicated to determining the importance level of each building discipline in Malaysian Anglican churches. However, the computation requires a few additional numbers to be established in order to obtain the decomposed weight for each building discipline. The goal of the AHP study is to establish the relative weight of each space type inside a church. Because generic assessments frequently treat all areas inside a building similarly, it has been demonstrated in the literature review that various places, particularly within religious facilities, may have varying levels of value. As a result, AHP receives the initial portion of the quantitative data collection and analysis. Second, various building components within a building discipline may have varying levels of importance, and the relative weight of each building component must also be determined. Thus, ANP was used to compare each building component inside each building discipline, as well as between building disciplines with respect to each building component.

The majority of responders to the pairwise comparison surveys are architects, maintenance managers, and asset/facility management consultants. With the exception of six respondents, the majority of the respondents had at least 5 years of work experience. The majority of respondents had a bachelor's degree or above, with only two having a diploma. Rather than generalising the areas inside a church, maintenance efforts should always focus on the most vital parts first. Expert surveys show that the chancel is the most important area of a church, followed by the nave. While crossing is considered a neutral area, the narthex and transepts are two of the least significant areas of a church.

Pairwise comparisons show that architectural and civil are significantly more important than electrical and mechanical. This finding supports the assumption made in the literature review that architectural and civil aspects are important in churches and frequently distinguish them. Aesthetics, thus, become one of the most crucial factors to be considered when maintaining churches.

Electrical and mechanical aspects are far less important than architectural and civil aspects. This is owing to the fact that electrical and mechanical components were few at the time these churches were constructed; electricity might not even be available. In most cases, these components are subsequent additions to churches for the comfort of the users. Although this conclusion does not negate the importance of electrical and mechanical components, it does emphasise the need for these components to avoid causing harm to the architectural and civil components of churches.

Data Availability

The respondent's particular, responses to questionnaires, and tabulation for ANP analysis data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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