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Identifying Building Defects: From Construction Cases in Malaysia

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Abstract

Statistics shows the construction industry giving impact 65% of Malaysia's economic development and triggered other national development sectors. The builder's ambition to make defects-free buildings that can save the budget allocation and have defects-free structures protecting the property inside the building is essential. When defects occurred (primarily due to water penetration towards the inside of the buildings); the valuable assets located inside will be damaged. The impact of these damages cost millions of Ringgit. This loss value can be reduced if proper and complete defects systematic preventive guidelines are on hand to relevant parties. However, no proper and complete documented guideline on how to get rid of the defects has been neatly produced. This research paper intends to identify complete building defects components and list the proper methods for solving them. Proper categorisation of the building components concerning the actual defects has been extracted from the real case studies gathered within the recent ten-year period. The qualitative research concluded that the need for systematic defects identification and tabulation of properly organised defects lists could help the related industry players eliminate all the defects, especially latent defects, in an organised and effective manner.

Disciplinary: Architecture, Civil Engineering & Building Technology.

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1 Introduction

There are about 300 billion square feet of existing buildings in the United States, most of which will still be standing in 2030. Existing buildings outnumber new construction by 99 to 1. We do not have time to renovate fully (resource-intensive) or replace (which is even more resource-intensive) this square footage. Operation and maintenance costs represent 60-85% of the expenditure over a building's lifetime (Carroon, 2010) and the case of Malaysia is no exception.

The longer the age of the particular building is, the more defects appear. It is shown that the type of defects usually occurs in the school buildings over 100 years; for example, in Perak, Malaysia is pretty similar to other heritage buildings in Malaysia (Alauddin et al., 2016). On the other hand, Snyder (1984) looks at the most molecular level building materials and building components such as stairs, windows, and air-conditioning ducts. The interest for architectural research is not in the properties of the materials or the components but in how they can be used in buildings. Combining architectural research and building technical knowledge can be a good combination of the method to solve the unique problem gap due to the seen and unseen building defects problem (Talib et al., 2015).

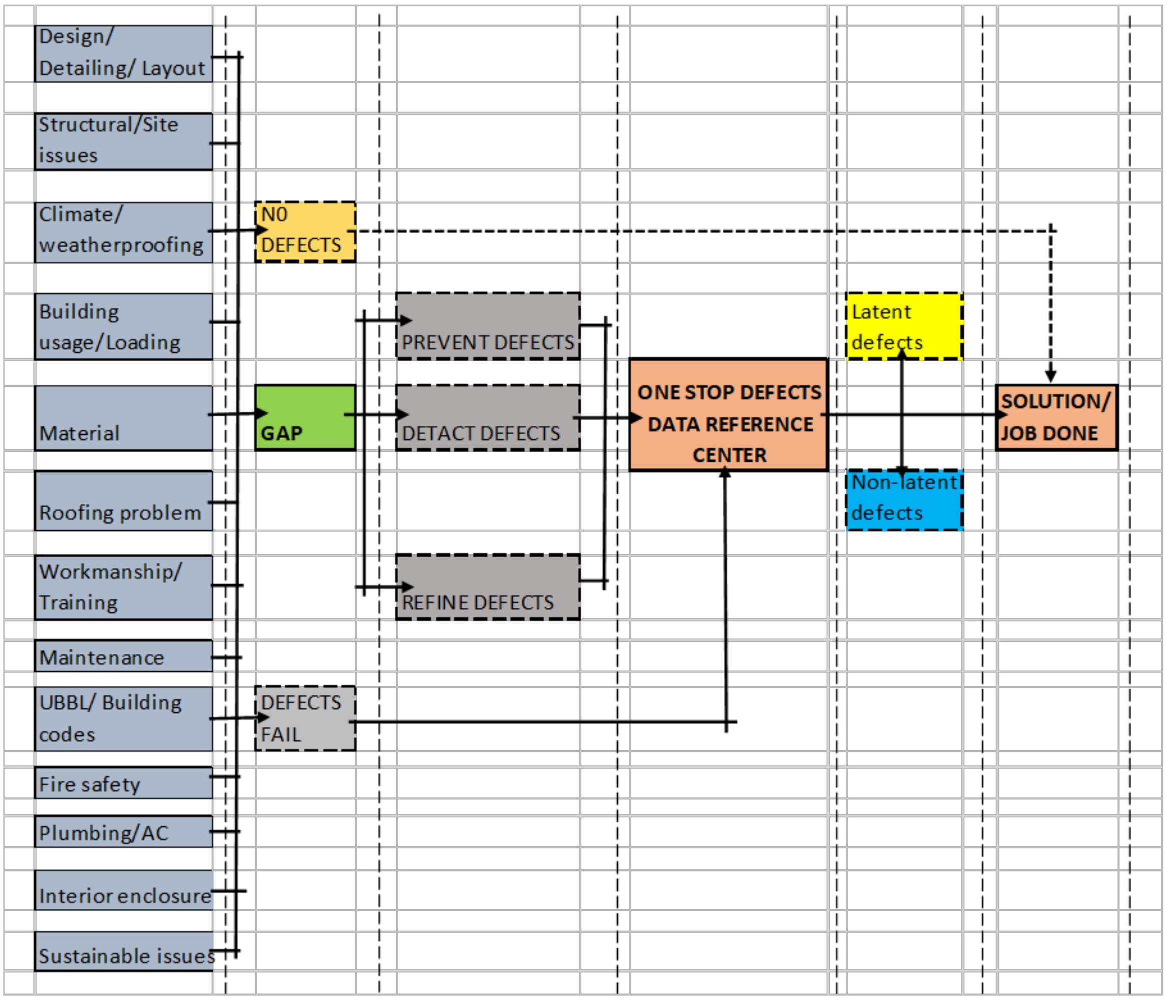

Figure 1: Flowchart of research activities.

With 13 separated factors formalised as the factors in creating the latent and non-latent defects shown in Figure 1, the gap among noticing the building defects is the leading research objective laid down questions.

2 Literature Review

All investigations that lay claim to being 'research' should start with a literature review (Denscombe, 2010). The literature review provides an outstanding foundation for researchers to investigate an innovative area by inducing them to review, assess and evaluate the initial study in a particular field of work (Bakar et al., 2017). A significant number of literature research sources from the related book's chapters and articles in indexed journal types concluded that insufficient considerations for the building failures causes were the key to preventing these defects. Looking from the design angle, the design strategies that could prevent these seen or unforeseen defects may come from over-load on flat roof allowable loads, preventing water leakage, improving specifications and improving design clarity, details, and layout. Standards and codes are available locally and internationally; however, each is designed specifically to overcome regional problems.

On the other hand, no single literature can provide everything people need to know to evaluate building systems or investigate building failures. However, research can provide valuable technical information regarding investigative techniques on defective subjects and provide invaluable tips on the evaluation and investigative process (Kubba, 2008).

3 Methodology

All methods employed for the research were to answer the research questions (Ariffin et al., 2015). However, computer methods are now used to coordinate better the research data collection, collation and dissemination of performance information of building defects through such projects as the Architecture and Engineering Performance Information Centre (AEPIC). Unfortunately, the AEPIC project has not yet become a valuable resource for design professionals, at least in the way it was envisioned originally to eliminate building defects (Feld & Carper, 1997). Therefore, for this research, the One-Stop Defects Data Reference Centre (OSDDRC), Figure 1, is the main target equivalent to AEPIC to be achieved. For this first phase of research, both quantitative and qualitative methods were used to study the hypotheses. However, the qualitative method seems primarily used as it is more relevant to the data found.

3.1 Qualitative and Quantitative Mix Methods Approach

As mentioned by Velmurugan & Dhingra (2015), the conceptual framework proposed for research is to help the industry players such as the maintenance managers assess, formulate, select suitable maintenance strategies and implement them for their organisation level. Fox & De Wilde (2016) prefer to use a qualitative method rather than quantitative analysis. From the results, it can be inferred that since qualitative defects detection was found to be less successful than a walk-through method, quantitative analysis using a pass–by methodology is unlikely to be accurate. Data accumulated from a comprehensive existing projects characteristics database and a supplementary questionnaire survey categorised from the quantitative research method provides in-depth knowledge of the defects correlations (Schultz et al., 2014).

The inductive and exploratory research used the factor approach in building the model to assess the research project's effectiveness. At the first level, the quantitative method would be helpful for testing hypotheses. At the second level, the problem was unstructured, and thus, the qualitative method would work to obtain a better understanding (Rasli, 2006).

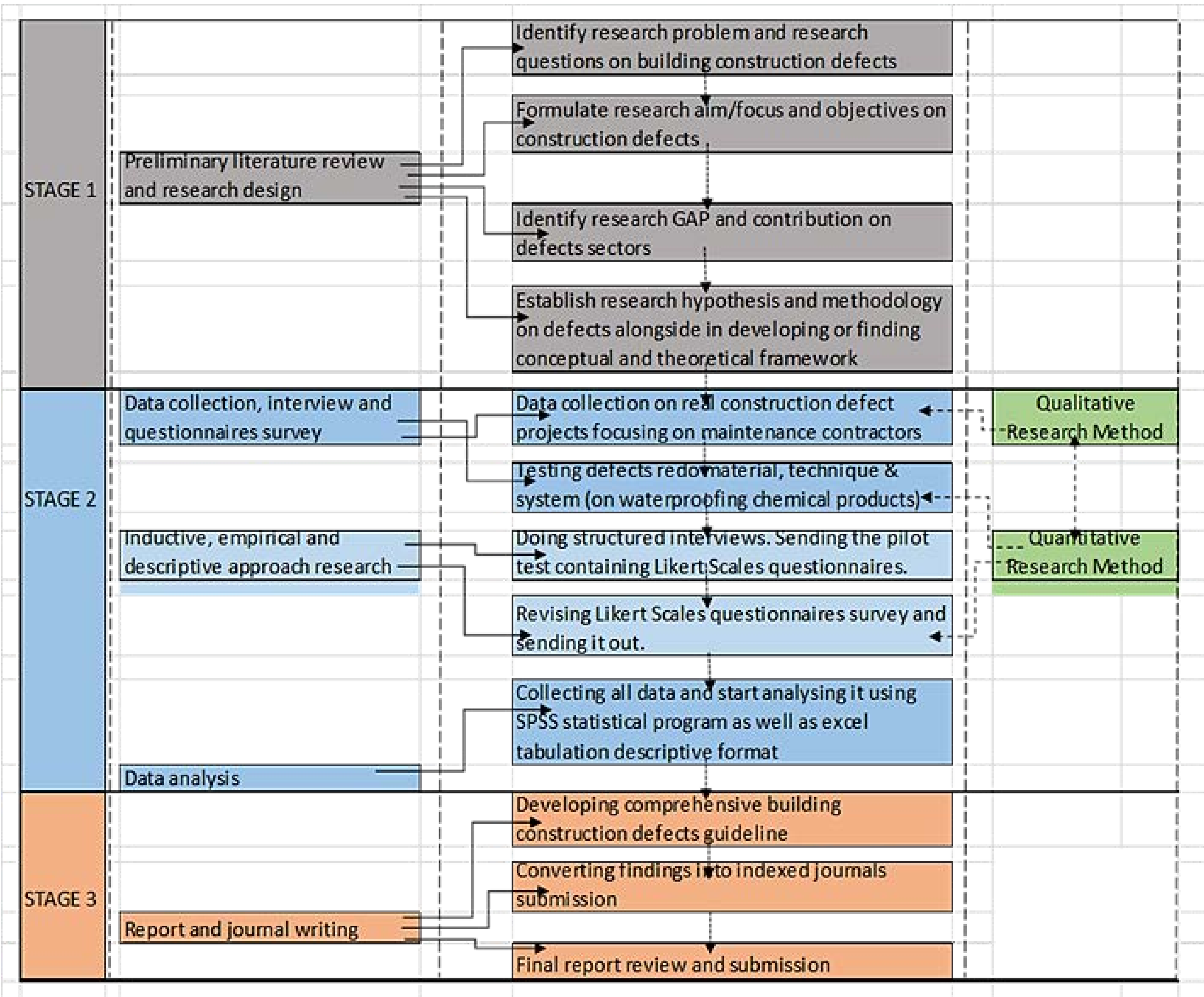

Figure 2: Methodological framework in doing the building defects research.

Figure 2 presents this research methodological framework. There are three stages identified with a literature review to be reviewed, data collection phase other than to come up with the formal report after analysing the data. In Stage 1, other than identifying all the related research questions and research objectives, it is essential to look for a study gap and underlining the potential hypothesis. In Stage 2, collecting data in the running through real construction projects focusing on the building defects regardless of their latent or non-latent is a great thing to do and enriching the data content in a qualitative research approach. This qualitative method of research thus can be converted to a quantitative one when those data are gathered together with technical information range from the chemistry content of the construction material used and its technical detail specifications. Lastly, Stage 3 will be focusing on writing up the finding either through indexed journals, book chapters or developing a construction defects guideline possible to be listed in proper website blog or even joint-venture further research with Government entity such as Public Works Department.

4 Result and Discussion

This article reviews the result from studying one qualitative data set from accumulating all the existing and previous building defects, especially to include the rectification waterproofing tasks done by four identified Specialist Waterproofing Contractors (SWC). The data is gathered from the projects identified from July 2019 until ten years ago circa 2009. Two of the SWCs still operating in Kuala Lumpur (K.L.) and Selangor area, while the other two relocated to Pulau Pinang. Most of the projects are located primarily in Pulau Pinang and K.L., while some are also located in Melaka, Negri Sembilan, Perak, or Kedah. This strategy of qualitative research is one of the first-hand encounters with a specific context. It evolves, gaining an understanding of how people in real-world situations "make sense" of their environment and themselves, and it achieves this by employing a variety of tactics. It acknowledges, rather than disavows, the role of interpretation in collecting and presenting data (Groat & Wang, 2002).

Roughly, the building where the project involved where the defects were found owned by 80% of the Government, including the GLC, and the other 20% belong to private companies. Therefore, it is estimated, during that ten years of data digging process done, approximately a total of 250 building types has been identified, with roughly about 200 (80%) buildings belonging to the GLC or the Government where the other 20% or about 50 buildings owned by private companies. The next stage of the research will be a quantitative research method to analyse the Likert Scale set of questionnaires with the pilot test. This is analysed using the SPSS®24 statistical data program to interpret the impacting numerical result and tabled for the following paper.

A total of 1,055 total defects, with 578 of them are latent and 477 are non-latent defects, see Table 1. Latent defects outnumbered the non-latent defects tabulated from 7 separation types of building components with 39 sub-components. For example, 53 defects of 318 total defects from the roofing category were found, with 32 latent defects. In contrast, 21 numbers of non-latent defects were found from the roofing defects using tile, the clay of concrete type of roof materials. Meanwhile, the minimum total defects found are only 13 defects, with seven on latent defects and six from non-latent tapping from the below-grade groundwater defects problem.

Chadderton (1991) indicated that below-grade drainage is designed to operate without energy input, wherever possible, to be reliable and require little, if any, maintenance. However, Table 1 shows 116 defects found on below-grade criteria, which involves the structure with 27 on foundation problems and 21 defects due to soil movement matters. The subsequent most defects found are air-conditioning condensation and dampness problems, with 48 defects, with 27 of them are non-latent, and 21 are from latent defects.

Table 1: Latent and non-latent building defects schedule accumulated from seven identified building components.

Item	Latent Defects	Non-latent Defects	TOTAL
ROOF	178	140	**318**
Tile/ clay/concrete	21	13	**34**
Bituminous felt	9	11	**20**
Asphalts	16	7	**23**
Zinc roof	22	12	**34**
Concrete flat roof	26	11	**37**
Metal roof	6	17	**23**
Roof tile/ clay/concrete	32	21	**53**
Gutter	17	11	**28**
Downpipe -Copper or p.v.c	11	16	**27**
D/P- aluminium corrosion	11	9	**20**
Parapet wall problem	7	12	**19**
SKYLIGHT	33	26	**59**
Glass	21	9	**30**
Polycarbonate	12	17	**29**
WALL Ext/Internal-Brick/concrete/plastered	168	122	**290**
A/C condensation/dampness	21	27	**48**
Rainwater penetration	17	11	**28**
Mould	17	9	**26**
Groundwater	7	6	**13**
Spalling	14	18	**32**
Stonewall defects	21	17	**38**
Granite wall defects	19	11	**30**
Timber wall defects	29	11	**40**
Wall paint defects	23	12	**35**
DOOR	34	37	**71**
Joints problems	12	8	**20**
Metal frame defects	9	12	**21**
Timber frame defects/rot	13	17	**30**
WINDOW	40	36	**76**
Aluminium frame defects	11	8	**19**
Expired sealant	12	9	**21**
Timber frame rot	10	11	**21**
Jamb, head, sill defects	7	8	**15**
FLOOR	62	63	**125**
Concrete floor crack	17	9	**26**
Moisture on floor underneath	9	8	**17**
Floating screed	11	12	**23**
Sulphate attack	8	7	**15**
Wood blacks floor - moisture /peel-off	5	9	**14**
Clay floor tiles broken	12	18	**30**
STRUCTURE	**63**	**53**	**116**
Foundation	15	12	**27**
Vegetation root	13	21	**34**
Leaf's clog roof water outlet	23	11	**34**
Soil movement	12	9	**21**
TOTAL/MAIN	**578**	**477**	**1055**

4.1 Defects Types- What, Why and Where It Has Still Happened?

A total of 578 latent defects and 477 non-latent defects was found from this case-studies actual projects observation. With a total of 1,055 latent and non-latent defects observation, most of both defect types happened on the roof part of the building. The top defect problems found during this exercise are on a Concrete Flat Roof (CFR) with 37 defects numbers, as shown in Table 1. It explains how the literature review found out in (Legal Research Board of Malaysia, 2005) UBBL 1984 (as of 2015) Part VI on Construction Requirements By-Law number 115 stated that all roofs of buildings should be so constructed as to drain effectively to suitable and sufficient channels, gutters, chutes or troughs. Therefore, it shall be provided following the requirements of these By-laws for receiving and conveying all water that may fall on and from the roof. Recording defects and classifying them into systematic categories help identify the defects, which defects are most probably caused by what, and which defects are most recurring. These are essential data that can be used to learn to identify what went wrong (Mohd Isa, Ismail, Zainol, & Othman, 2016).

Table 2: Minimising building failures: Roof and wall components.

CASES HAPPENED	Roof				Wall						
MINIMISING BUILDING FAILURES	Concrete flat roof	Tile roof	Metal roofing	skylight	Internal	External	Door	Window	Floor	Structure	Total/ main
Need to have a fast track and shorter construction period	14	9	11	5	4	5	5	6	8	6	**73**
Target on defects free buildings syndrome	21	11	17	8	5	6	7	6	7	8	**96**
Preventing regular and irregular flooding.	7	8	5	0	4	4	7	0	11	12	**58**
Minimise and avoid buildings vandalism	14	9	8	6	11	19	12	15	12	11	**117**
Avoid misguided application of waterproofing/sealant materials	34	9	12	12	16	17	11	17	12	11	**151**
Fulfil unexpected user requirement	14	7	16	9	16	11	9	8	12	7	**109**
Simplify complex framework on construction industry	13	12	9	7	5	5	8	8	4	7	**78**
Avoid cheapest bid win the tender may lower work quality.	15	12	9	11	11	9	8	6	8	5	**94**
Improved feedback from industry players.	21	11	12	18	8	12	9	8	7	6	**112**
Improved construction drawing details.	31	21	12	12	21	26	11	12	14	5	**165**
Regular job training on defects maintenance program.	7	8	9	7	8	8	7	9	7	4	**74**
Produce and make available proper defects avoidance guidance checklist.	12	8	9	6	7	6	6	11	10	4	**79**
Introduce more sophisticated building systems (i.e. IBS) to avoid defects.	7	5	6	5	7	7	9	11	6	5	**68**
MAIN/TOTAL	**210**	**130**	**135**	**106**	**123**	**135**	**109**	**117**	**118**	**91**	**1274**

There were 1,274 total number building defects from this schedule analysis as tabled in Table 2 for reference. The cases focused only on the roof and wall defects, including the other building components, including the door, window, floor and structure related defects. The analysis of Table 2 summarised within 13 categories of aspects to minimise the building defects. The highest number of defects saved, with 165 of them, came from improving the construction drawing details. Next, avoiding the misguided application of the waterproofing and building sealants materials helped saved 151 defects cases. 210 total defects have been identified from the CFR cases extracted from 13 categories identified factors to minimise the building failures. After the highest defects category with 210, the next is that both 135 building defects have been identified upon the metal roofing problem and the external wall. As far as the minimum defects are concerned, 58 and

91 defects have been accumulated regarding preventing regular and irregular flooding seeping through the interior and a total defect regarding the problem of the building structure.

Table 3: Defects on exterior and interior – From leaking to peeling-off.

Item	Leaking	Cracking	Moving/ Detach	Clogging	Blistering	Splitting	Under sizing	Rusting	Making Holes	Sagging/Shrunk	Deteriorating/ Defective	Expired (sealant)	Loose	Decaying	Collapsing	Lifting/curling	Peeling/Flaking	Damp-rising/ Moisture (algae/mould)	Total (1536)
EXTERIOR																			
Foundation	0	16	0	0	3	1	0	0	7	8	0	0	0	0	5	4	0	14	58
Landscaping - tree, weed	0	12	2	18	2	2	0	0	3	4	0	0	0	0	4	9	5	0	61
Roof	17	12	8	17	9	5	0	0	6	8	1	9	0	0	3	6	12	0	113
Gutter and downspouts	16	9	8	21	0	6	18	15	9	8	5	0	11	0	7	4	0	0	137
Ext. Brick wall	12	21	7	0	4	4	0	0	7	6	7	0	6	6	6	0	0	0	86
Ext. Concrete wall	19	16	4	0	5	2	0	0	5	4	4	0	0	4	5	2	5	0	75
Ext. Timber siding	6	4	11	0	5	6	0	0	9	9	12	0	15	7	4	7	12	0	107
Ext. Water tank	17	3	3	7	0	0	0	7	9	0		0	6	0	3	0	0	0	55
Air-Cond piping	19	0	15	0	0	0	9	0	6	6	0	0	6	0	5	0	0	0	66
Door	12	3	5	0	2	3	0	0	1	3	11	0	4	5	5	6	1	0	61
Window	16	8	3	0	0	0	4	0	0	6	5	12	0	0	0	4	0	0	58
Balcony/ Deck	17	7	5	5	0	0	0	0	7	0	0	0	0	0	0	0	0	0	41
Planters box	16	8	0	8	0	0	0	0	4	0	0	0	0	0	0	0	0	0	36
Roof top swimming pool	6	4	0	6	0	0	0	0	0	0	0	3	0	0	0	0	0	0	19
INTERIOR																			
Wet areas, i.e. Toilet, shower, wuduk, kitchen	19	5	2	4	1	0	0	0	12	3	1	0	0	0	4	3	5	12	71
Floor/Concrete/Timber, Linoleum/ Tiled	11	12	7	0	4	4	0	0	4	5	5	0	2	0	5	9	5	0	73
Int. Brick wall	11	8	3	0	2	0	0	0	5	5	3	4	2	0	4	0	0	12	59
Int. Concrete wall	9	7	3	0	1	0	0	0	5	7	3	4	3	0	4	0	0	9	55
Int. Timber, gypsum etc. wall	3	9	3	0	6	6	0	0	5	5	4	0	4	4	0	3	9	0	61
Ceiling	21	23	9	0	3	8	0	0	11	9	0	0	5	0	5	5	5	0	104
Fire protection system -sprinklers, alarms, fire distinguishers, smoke detector, etc.	0	0	0	0	0	0	0	0	0	0	0	0	8	0	8	0	0	0	16
Lift -pit	21	12	0	0	0	0	0	0	0	0	0	4	0	0	2	0	0	0	39
Boilers room	9	8	0	0	0	0	0	0	0	4	0	4	0	0	0	0	0	4	29
Pump-sump	7	7	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0	4	23
Int. Water tank	5	5	2	4	0	0	0	4	0	0	0	6	3	0	0	0	4	0	33

One of the many factors that need to be refined to prevent the defects, latent or not, is a maintenance factor that faces many challenges. Such as optimisation of operation and maintenance function due to the continually evolving world of technologies, global competitiveness, environmental and safety requirements (Velmurugan & Dhingra, 2015). Most buildings can be considered porous since there is a facility for air to move through them. This may be part of the general provision of natural ventilation or poorly jointed material, components and elements. Air-porous buildings may contain passageways that can be exploited by water and water vapour entry. The size and shape of pathways may change with the wind pattern, as in the chattering slates and flapping felt in pitched roofs (Cook & Hinks, 1992). The building envelope is equivalent to the skin of the building. In essence, a structure must be enveloped from top to bottom to prevent intrusion from nature's element into the interior spaces and protect the structural components from weathering and deterioration (Kubal, 2008).

For this defects tabulation exercise (as in Table 3), a total of 1,363 building defects has been accumulated from 14 exterior factors and ten internal factors of the building envelope components; with 18 number defects categories ranging from leaking, clogging, rusting or damp-rising; a total of 1,536 number of defects has been detected. A sum of 137 defects has been recorded from the analysis table as the highest number coming from the gutter and downspout defects problem. The minimum number of defects found from the defects of fire protection systems, such as the problem coming from the sprinkler, alarm, fire extinguisher or smoke detector problem, with only 16 defeats.

They were cracking problems either from the building's exterior or interior part, giving the highest defects problem with 219 defects. It is crucial to determine the cause of cracks, while their width, position and direction, and the degree of exposure are all matters that will help decide what action should be taken. British Standard Code of Practice, BS8110: Part2, The Structure Use of Concrete, recommends a maximum crack width of 0.3mm for general conditions. Crack widths are measured at the surface of the concrete, and it is assumed that they reduce in width reasonably rapidly as the cracks extend inwards (Perkin, 1997).

The under-sizing of the gutter, downspout and the air-conditioning pipe is the least number of defects collected with only 31 defects. (Kubal, 2008) stated that 90% of all water intrusion problems occur within 1% of the entire building or structure exterior surface area. This 1% is all too frequently leads to breaches and complete failure of the effectiveness of the building envelope and is the leading cause of waterproofing problems.

Harris (2001) stated that people could not have specific knowledge, nor can we exercise complete control over deterioration. As buildings age, the lines of stiffness shift; the load-carrying distribution within the structure changes; at the macro-scale, no-load bearing elements begin to carry the load. Moreover, Schultz et al. (2014) outlined that the competency themes on having quality working skills among the construction worker are at number 5 among the nine categories identified and worth concern and observing.

Regular job training, especially on the defects maintenance program, must be implemented to reduce the number of defects from the unskilled labour factor. Interestingly, it is reported that over 3 million Indonesian who stayed and worked in Malaysia mainly contributed to the local construction sector, as mentioned by the Indonesian Ambassador-in Malaysia (Ismail, 2019).

However, most Indonesian workers were not specially trained in building construction, especially building works like waterproofing tasks.

With The Fourth Industrial Revolution (IR 4.0) on hand and expected to change the way we live, work and communicate, current active players within the construction industry in Malaysia must think positively in tackling the building defects syndrome systematically. This is to ensure high quality of buildings with zero defects tolerance can be realised. As indicated from this study, the ten-year survey revealed that there are still too many defects that still existed on the daily construction scene in Malaysia, whether the defects happened during the pre-construction period, during construction time itself or the post-construction period. This situation must be taken seriously on how to reduce them effectively. Even though the university courses on the construction syllabus matter are highly accredited with specific standards, mistakes have been made and repeated in the 'real world'.

5 Conclusion

With the total defects accumulated for latent and non-latent defects and exterior and interior defects with identified 18 building defect types from leaking to damp-rising, there is an essential need for the development of comprehensive preventive maintenance programs (Dickerson & Ackerman, 2016). Door and window contributed among the top defects problem.

Defects accumulated from the door and window are with problems mainly from the leaking, expired window sealant, and defective door frames. Fox et al. (2016) revealed 94% of the ventilation heat loss defects came from windows, whilst none were detected from structural draughts. This might have been due to the increased number of windows than doors and common weakness found at the seal between windows and frames. Excess heat loss from doors and windows could significantly contribute to overall dwelling thermal performance and occupant thermal comfort. Depicting just from the Exterior and Interior components of the building, all the reparative works on those defects for that particular part of the defect matters not replacing the whole part. Yes, to repair it and not to replace the whole thing! Repair rather than replacement creates an economy that values and employs local craftspeople, extends the life of products, keeps construction waste (or materials requiring recycling) to a minimum and reduces the need for new products. That, by definition, has a negative environmental impact – regardless of how they were manufactured or the amount of recycled material they contain (Carroon, 2010).

To target having more efficiency in constructing the building, certain aspects of refinement must be done, either it started from the academic level or to the authority body like CIDB. The gap must have clearly been defined only to get the centralise defects databased running to ease up the players in doing their job more efficiently, at least for a start. Hamid (2010) summarised that buildings and sites must be socially harmonised blended with the residents; young human or matured has been spelled out in the Al-Quran and Sunnah. As an individual, Government agency, property developer, architect or engineer, everybody or each party has a part to contribute to a better generation. From this study, buildings defects could not get rid-off, no matter how efficient the systems are. However, it can be started to minimise the defects first, then targeting on zero-defects mission afterward.

6 Availability of Data and Material

Data can be made available by contacting the corresponding author.

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8 References

Alauddin, K., Ishakt, M. F., Isa, H. M., & Sohod, F. M. (2016). The observation of defects of school buildings over 100 years old in Perak. In *MATEC Web of Conferences* (Vol. 66).

Ariffin, N. A. M., Rashid, M. M. & Salleh, N. H. (2015). *Methodologies in architectural research*. http://www.mbpjlibrary.gov.my:8081/webopac/Record/0000197934

Bakar, A. H. A., Roosli, R., Kamal, E. M., & Rashid, Z. Z. A. (2017). *A Complete Guide to Academic Research In Built Environment and Engineering*. https://books.google.co.th/books?id=UaxoDwAAQBAJ&pg=PT74&dq=A+Complete+Guide+to+Academic+Research+In+Built+Environment+and+Engineering

Carroon, J. (2010). Sustainable preservation: greening existing buildings. Wiley.

Chadderton, D. V. (1991). *Building services engineering*. E & F.N. Spon.

Cook, G. K., & Hinks, A. J. (1992). Appraising building defects: perspectives on stability and hygrothermal performance. Longman Scientific & Technical.

Denscombe, M. (2017). The Good Research Guide: For Small-Scale Social Research Projects. McGraw-Hill Education (UK).

Dickerson, D. E., & Ackerman, P. J. (2016). Risk-based Maintenance Management of U.S. Public School Facilities. *Procedia Engineering*, 145. DOI: 10.1016/j.proeng.2016.04.069

Feld, J., & Carper, K. (1997). *Construction failure*. Second Ed., New York, NY USA: John Wiley & Sons.

Fox, M., Goodhew, S., & De Wilde, P. (2016). Building defect detection: External versus internal thermography. *Building and Environment*, 105, 317-331. DOI: 10.1016/j.buildenv.2016.06.011

Groat, L. N., & Wang, D. (2002). *Architectural research methods*. https://elib.usm.my/cgi-bin/koha/opac-detail.pl?biblionumber=253605

Hamid, S. A. (2010). Islamic building design : beyond calligraphy and domes. Retrieved from http://pusatsumber.kkmm.gov.my:8080/webopac20/Record/0000030065

Harris, S. Y. (2001). *Building pathology : deterioration, diagnostics, and intervention*. https://www.wiley.com/en-my/Building+Pathology:+Deterioration,+Diagnostics,+and+Intervention-p-9780471331728

Isa, H. M., Ismail, K., Zainol, H., & Othman, M. F. (2016). Tracking architectural defects in university buildings in Malaysia. *MATEC Web of Conferences*, 66, 00017. DOI: 10.1051/matecconf/20166600017

Ismail, M. A. (2019). *Tiga juta warga Indonesia di Malaysia*. Utusan Melayu (M) Bhd, 65p. http://www.utusan.com.my/berita/nasional/tiga-juta-warga-indonesia-di-malaysia-1.918152

Kubal, M. T. (2008). *Construction Waterproofing Handbook*. 2nd Ed.

Kubba, S. (2008). *Architectural forensics*. McGraw-Hill.

LRBM. (2005). *Uniform Building By-Laws 1984*. G.N. 5178/85. Legal Research Board of Malaysia. https://books.google.com.my/books?id=uPhrAQAACAAJ&dq=Uniform+building+by-laws+international+law+book+services

Perkin, P. H. (1997). Repair, Protection and Waterproofing of Concrete Structures. 3rd Ed., CRC Press.

Rasli, A. (2006). Data analysis and interpretation: a handbook for postgraduate social scientists. http://eprints.utm.my/id/eprint/30009/

Schultz, C. S., Jørgensen, K., Bonke, S., Mikael, G., & Rasmussen, G. (2014). Building defects in Danish construction: project characteristics influencing the occurrence of defects at handover. DOI: 10.1080/17452007.2014.990352

Snyder, J. C. (1984). *Architectural research*. https://elib.usm.my/cgi-bin/koha/opac-detail.pl?biblionumber=358480

Talib, R., Ahmad, A., & Sulieman, M. (2015). Building Design Failure. Why Did It Fail? How Could It Have Been Avoided? *International Journal of Chemical, Environmental & Biological Sciences*, *3*(5), 372-378.

Velmurugan, R. S., & Dhingra, T. (2015). Maintenance strategy selection and its impact in maintenance function: A conceptual framework. *International Journal of Operations and Production Management, 35*(12). DOI: 10.1108/IJOPM-01-2014-0028

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