THE IMPACT OF LATENT DEFECTS ON THE PUBLIC BUILDINGS IN MALAYSIA

ROSLAN BIN TALIB

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THE IMPACT OF LATENT DEFECTS ON THE PUBLIC BUILDINGS IN MALAYSIA

by

ROSLAN BIN TALIB

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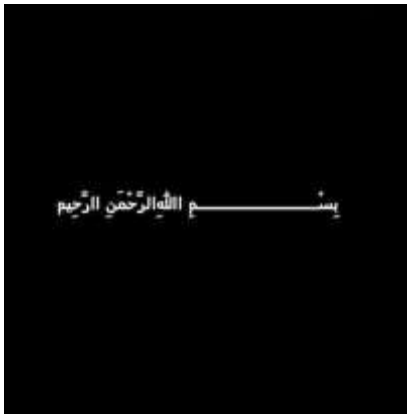

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I dedicated this thesis to the soul of my late father

الفاتحة

Thank you for your encouragement

"Mencari ilmu itu tidak dikira usia nya…"

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LIST OF SYMBOLS

($\chi 2$)	Pearson's Chi-square test
($\bar{x}$)	Mean or average
$\tilde{x}$ "x-tilde	A simple measure of central tendency/ median
p-value	the measure of the probability
n or *N* or Ω or 'μ'	Cases in population
σ, σ_x or SD	Standard Deviation
(S^2)	Variance
Var*(x)* or σ2	Denoted as Range
X	Independent Variable
Y	Dependent Variable
t-test	Use to compare the values of the means
'Σ X_i'	Sum of all scores present in the population (say, in this case) X_1 X_2 X_3 and so on

LIST OF ABBREVIATIONS

BILS	BUILDING INTERIOR LEAKAGE SYNDROME
BLD	BUILDING LEAKAGE DEFECTS
BLS	BUILDING LEAKAGE SYNDROME
BOMBA	BADAN ORGANISASI MENYELAMAT BENCANA ALAM (NATURAL DISASTER RESCUE ORGANIZATION)
CCPM	CERTIFIED CONSTRUCTION PROJECT MANAGER
CFR	CONCRETE FLAT ROOF
CDB	CENTRAL DATABASE
CIDB	CONSTRUCTION INDUSTRY DEVELOPMENT BOARD
CDRGH	COMPREHENSIVE DEFECTS REFERENCE GUIDELINE HANDBOOK
CFW	CONCEPTUAL FRAMEWORK
D.L.P.	DEFECT LIABILITY PERIOD
EPA	ENVIRONMENTAL PROTECTION AGENCY (USA)
FGD	FOCUS GROUP DISCUSSION
GLC	GOVERNMENT LINK COMPANY
GF	GOOGLE FORMS
G.O.M.	GOVERNMENT OF MALAYSIA
HBG	HISTOGRAM BREAKDOWN GRAPH
HT	HYPOTHESIS TEST
JKR	JABATAN KERJA RAYA (PUBLIC WORKS DEPARTMENT)
LA	LOCAL AUTHORITY
LEED	LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN
LR	LITERATURE REVIEW
LS	LIKERT SCALE

MoF	MINISTRY OF FINANCE
PMC	PROJECT MANAGEMENT COMPANY
POE	POST OCCUPANCY EVALUATION
PSP	PRINCIPAL SUBMITTING PERSON
PU	POLYURETHANE
QA	QUALITY ASSURANCE
QC	QUALITY CONTROL
QL	QUALITATIVE
QN	QUANTITATIVE
RWDP	RAINWATER DOWNPIPE
SDB	STREET, DRAINAGE AND BUILIDNG
SME	SUBJECT MATTER EXPERT
SWC	SPECIALIST WATERPROOFING CONTRACTOR

LIST OF APPENDICES

IMPAK KECACATAN TERSEMBUNYI TERHADAP BANGUNAN AWAM DI MALAYSIA

ABSTRAK

Kecacatan bangunan menjadi masalah yang lebih rumit daripada apa yang kita fikirkan dan sangat mempengaruhi aset berharga yang terdapat di ruang dalaman apabila berlaku kerosakan; terutama kecacatan kebocoran berlaku. Penyelidikan literatur menunjukkan bahawa berbanding dengan kebakaran atau kecacatan struktur; kecacatan bangunan memberikan senario yang lebih bermasalah apabila kecacatan berlaku tanpa boleh dapat dilihat atau ianya terpendam. Lebih teruk lagi apabila kecacatan *"latent"* (terpendam) muncul semasa peringkat pra, semasa atau selepas pembinaan. Oleh itu, tujuan kajian ini adalah untuk membolehkan tiada kerosakan pembinaan dihasilkan. Dengan kecacatan bangunan yang sifar atau kurang yang mempengaruhi bahagian luar atau bahagian dalam bangunan, kualiti bangunan akan berada pada tahap tertinggi dan mendorong nilai komersial bangunan tersebut. Seterusnya, objektif kajian ini adalah untuk mengawal kerosakan bangunan agar tidak terus berlaku dan terus berulang. Sudah tiba masanya, sesuatu perlu dilakukan untuk mengelakkannya, dengan serius. Dimulakan dengan ujian rintis, mengumpulkan data projek sebenar yang komprehensif, sesi siber **FGD**, temu ramah tatap muka serta tinjauan dalam talian yang sistematik; penyelidikan dapat mengumpulkan cukup banyak data berkualiti yang layak untuk menyokong kesimpulan kajian yang kuat. Akhirnya, penemuan mengukur bahawa kecacatan bangunan; tidak kira ia pendam atau tidak; masih memainkan peranan utama dalam memberi gangguan kepada pemain pembinaan bangunan. Dengan pengumpulan data kecacatan yang lengkap, analisis statistik yang komprehensif dan terperinci dapat dilakukan secara sistematik; untuk

membuktikan hipotesis yang digariskan dan mengisi jurang kajian. Selain itu, analisis-analisis statistik dari kaedah campuran data kuantitatif dan kualitatif dan melalui analisis triangulasi, membuktikan bahawa masih terdapat terlalu banyak variabel kecacatan yang perlu ditangani. Hasil kajian juga mengemukakan faktor-faktor terperinci yang mendasari kewujudan topik kecacatan pembinaan bangunan terutama mempengaruhi ruang dalamannya dan mencadangkan pilihan dan strategi yang lebih holistik untuk mengatasi masalah tersebut. Sekali lagi, dari bukti statistik menyeluruh yang dilakukan, adalah mungkin penyelidikan ini dapat memberi kesedaran dan membina sentimen yang lebih kuat kepada para pemain pembinaan untuk memperbaiki kekurangan keseragaman dan ketidakkonsistenan dalam bukti statistik dalam memperbaiki kecacatan bangunan. Terakhir, penyelidikan ini telah dapat menambahkan data baru pada literatur yang ada dan memberikan banyak maklumat kecacatan bangunan dalam meningkakan kualiti ruang dalaman bangunan terutama bangunan awam di Malaysia pada masa depan.

THE IMPACT OF LATENT DEFECTS ON THE PUBLIC BUILDINGS IN MALAYSIA

ABSTRACT

Building defects become more complex issues than what we are thinking and affected severely to the valuable assets found within the interior spaces when real defects; the leakage defects occurred. Literature research revealed that compared to fire or structural defects; building defects provides more problematic scenarios upon plummeting with seen or latent defects. Eviler anticipated when latent defects arise during pre, during or post-construction stage. Thus, the purpose of the study is steering to aim at having nil construction defects. With zero or fewer building defects affected the exterior or the interior of the building, the quality of the buildings will be at the highest and impetus the building's commercial value. Next, the objective of the research is to control building defects from keep on happening and keep on repeating them. It's about time, something needs to be done to prevent it, seriously. Initiated with the PILOT test, accumulating comprehensive real project data, **FGD** cyber sessions, face to face interviews as well as systematic online survey; the research can accumulate enough amount of quality data eligible to support strong study conclusion. Finally, the findings measured out that building defects; regardless it's latent or none; still play a foremost part in giving nuisance to the building construction players. With the mammon collection of defects data, the comprehensive and detailed statistical analysis can be done systematically; thus, proving the suggested outlined hypotheses and filling out the research gaps. Besides, the statistical analysis exercise from the quantitative and qualitative data mixed-method approached and through the triangulation analysis, proved that there are still too many defective variables required

to be addressed to and to tackle. The research findings also tabled out detailed factors that prejudiced the existence of the building construction's defects topic especially affecting its interior space and suggested more holistic options and strategies in tackling the problems as well. Again, from the thorough statistical evidence done, this research is possible to give an impact to the industry and establishing stronger sentiment to the construction players to improve on the lack of uniformity and inconsistencies in statistical evidence in improving building defects. Lastly, this research somehow has added new data to existing literature and provided a good and wealth of information concerning improving the quality of the interior space of future buildings especially for public buildings in Malaysia.

CHAPTER 1

INTRODUCTION

1.1 Background of Study - on Defects

1.1.1 Building Defects 101

Buildings have been built all over and repeatedly to meet the demand in every part of the world. To look at from a global perspective, this construction scenario has become a typical and regularly scene that started after WWII (specifically from 1945), and it continues and never stop until now; the IR4.0 era. According to the Global Construction Market (A.C.M.) report in August 2018, the construction process involves colossal investment. Global construction output is forecast to rise to US$12.7 Trillion in 2022, up from US$10.6 Trillion in 2017. The global economy will continue to post healthy growth rates in 2018-2019 even investor confidence will remain buoyant. Moreover, according to PLANGRID and F.M.I. survey on eSUB construction Software's January 2019 report, the construction industry spends roughly US$178 Billion per year on just fixing 'error's within the U.S. construction industry!

With the considerable investment value cost to construct the buildings, the related parties are still a big issue, such as handling building defects. According to Quality Built (Q.B. L.L.C.) with offices in Fort Lauderdale, Florida and San Diego, California, U.S.A., a report in March 2019 stated that US$650.00 is a standard cost required to do a house inspection in the U.S. The house inspection survey revealed (from 2,000,000 data bank source) that most of the defects found are from interior and exterior wall problem (originating from cladding stucco), roofing's flashing and wrong product specification and design failures. The repair cost will vary depending on the

cause of the cracking, ranging from US$1.00 per square foot of the affected wall plane to as high as US$114.00 per square foot!

On the other hand, the U.K.'s Chartered Institute of Building (CIOB) stated that poor quality, a.k.a building defect, cost the industry annually more than the industry's combined profits in the industry quoted in an article in September 2018. CIOB claim on their recent research suggesting better quality on construction management could save the industry up to £12 Billion a year. CIOB's quality commission was launched in 2017 amid a spate of building failures, including public office buildings, more than 80 Scottish schools, and public complaint about building defects and new houses built by the British Government's developers. The low quality of buildings affects the property market, and it needs a specific budget to get it into the marketable level and a proper maintenance schedule.

Locally, Malaysia construction scene is no contrast in terms of taking care of building defects issue. The situation gets to be wickedest when it involved building defects starting from water spillage, particularly from the rainwater. As Malaysia is located within tropical locales, water continuously becomes a challenge to the construction players in managing the Building Leakage Syndrome (B.L.S.) issue. The Government of Malaysia (G.O.M.) utilised to spend RM100 Million to do the material rectification works in managing the rehashed spillage in 2010. Taking a good media covered for a case, the leakage issue of the noted Parliament Building located right in the middle of Kuala Lumpur. This conspicuous noteworthy building was built in 1967 utilised to have the same leaking issue in 2005 and 2009 and affected the valuable interior possessions such as its characteristic timber pieces of furniture and recently restore hi-tech sound system framework. In another case, KLIA2 new air terminal

allegedly went through another additional RM270 Million to do all the absconds defects correction work in 2016 (see Table 1).

Furthermore, in another case, from a report in March 2010, 3 new blocks of G.O.M.'s teachers' housing blocks (2 blocks in Kedah and 1 in Pulau Pinang) were incapable of proceeding to be possessed indeed after the rectification construction work just completed within three months period due to unsolved defects issue. It is reported that most of the defects derived from the un-standard construction method of the pre-fabrication construction system being implemented by the builder. In a later report (July 2019), the P.G.A. Police housing quarters in Ulu Kinta, Perak was confronting serious leaking issues each time the weather conditions are pouring. The quarters were built from 1967-1981 by G.O.M. initially having 27 blocks with ten and 12-floor blocks, whereas as of now, three blocks unsafe to stay in due to missing legitimate maintenance, mainly due to Building Leakage Syndrome (B.L.S.) issue (see Table 1).

Consequently, this research morphology deliberately focuses the study scope on the building defects [latent or non-latent including on Building Leakage Defects (B.L.D.) problem] mainly on the Government of Malaysia (G.O.M.) owned buildings and their impact on the **INTERIOR SPACE** precisely and on the whole building components in broad-spectrum. Overall, leakage defects need distinct devotion among the construction players and tactics must be drawn on in what way to overwhelmed or diminish them systematically. Typically, general defects happen either because of deprived design or bad-quality workmanship or because the building was not erected according to the design details or because it has been subject to factors inadmissible for the design (National Building Agency., 1979). These principal causes may function

independently or in an amalgamation mixture of those factors. Furthermore, data result in defects indicated that changes in the composition of materials (in the construction itself), in size, shape (or weight of materials or parts of a building), or simply appearance; can trigger building defects to happen.

According to (Kubal, 2008), 90 per cent of all water disturbance hitches (through and towards the interior part of the building) happen within 1 per cent of the total building structure external surface part. Even the greatest well-known cases include building like Frank Lloyd Wright's Falling Water and Philip Johnson's Glass House (considered as their magnum opus work); furthermore, however these locales have become meccas for current connoisseurs, they are not without their issues. Worked without the present cutting-edge innovation, numerous pioneer structures experience the ill effects of flawed rooftops, best case scenario, and primary insecurity even from a pessimistic standpoint, no doubt arousing a lot of disappointment for individuals who appointed them (Allen, 2016).

1.1.2 Leakage Defects - The Syndrome

The Government of Malaysia (G.O.M.) has consumed Millions of Ringgits on building new constructions and maintaining them such as schools, hospitals, and public offices to guarantee the finest building quality delivered by the Government can be provided to the public. According to a report by (treasury.gov.my, 2018), a total of RM2.005 Billion gentrification budget is allocated to manage and maintain the national infrastructures, including maintaining public buildings and RM3.266 Billion allocated directly to build new infrastructures, including Government-owned roads as well as Government buildings. As a fast-developing country and is forthcoming the

rank of an advanced country by 2025 after its first target in 2020, together with the IR4.0 era, the G.O.M. circuitously paid a significant budget assignment to guarantee the inside and outside condition of these Government-possessed structures are at its most satisfactory condition. An aggregate of monetary arrangement likewise held to play out the upkeep segment on these structures is massively allotted to the best state.

It ought to be noticed that other than developing and keeping up with the structures, the G.O.M. must also devote a great deal of financial plan allocation to fill the interior of the said structures. Each building built should be engaged with different things going from all kind of furniture to PC centralized computer contraptions worth Tens of Thousands or Millions of Ringgits tracked down solely inside each structure. Situations where the Parliament Building was leaking because of weighty downpours in April 2005 due to the disappointment of the material's waterproofing framework and harmed significant wood apparatuses inside the Parliament building, and it was happened again in May 2008 this time because of RWDP flood are very unsettling (see Table 1). A recent statistics table by Malaysia’s Minister of Finance (Tengku Abdul Aziz, 2020) stated in the G.O.M.’s 2021 Financial Expenditure Statement, a total of RM2.7 Billion has been allocated for the maintenance of the non-urban infrastructure facilities alone. Specifically, an additional sum of RM800 Million has been allocated to maintain and fix the 50 identified disrepair schools as reported by (Abdmutalib, 2020).

Building leakage still keeps on occurring on the current buildings in any portion of the globe; however, the effect can be more unembellished, particularly to the structures situated within the wet humid meteorological conditions like Malaysia. It seems like Malaysia is in the middle of the perfect storm, typologically speaking

when it comes to building defects. A construction boom that saw some developers, project managers and builders cut corners to meet demand coupled with the weakening of regulatory oversight has seen defects rain down on building owner. Leakage absconds still require exceptional consideration among the development players, and techniques should be attracted to survive or limit them thoroughly. Other than B.L.S., the primary agents affecting the existence of the defects may vary due to the wear and tear, applied powers (ground development, traffic vibration), gases or fluids (sogginess, synthetic assault), organic specialists (decay, shape and parasites), environment or temperature and fire (*Common Building Defects - Client Seminar - July 2014 - YouTube*, 2014).

Took 432 Park Supertall Condo building in New York City, USA, once the tallest residential building in the world, faces some significant design problems including water leakage damage from plumbing and mechanical issues; frequent elevator malfunctions; and walls that creak like the galley of a ship! The first reports of defects and complaints are beginning to emerge, raising concerns that some of the construction methods and materials used have not lived up to the engineering breakthroughs that only recently enabled 1,000-foot-high trophy apartments. There have been several floods in the building, including two leaks in November 2018 that the general manager of the building, acknowledged in emails to residents. The first leak, on Nov. 22, was caused by a "blown" flange, a ribbed collar that connects piping, around a high-pressure water feed on the 60th floor. Four days later, a "water line failure" on the 74th floor caused water to enter elevator shafts, removing two of the four residential elevators from service for weeks.

1.1.3 IR4.0 and Aged Building Defects

The construction industry all around the globe is getting modern, advance and growing day by day. Despite the development, the construction industry is dealing with one major problem, i.e. building defects. Building industry players constantly strive to overcome defects in buildings, but it is challenging to deal with them altogether (Singh & Kaur, 2019). With Fourth Industrial Revolution (IR 4.0.) on hand and trajectorially expected to change how we live, work and communicate; the construction industry in Malaysia; on the other hand; seems to be in static mode instead of making the construction industry's defects tackling scenario in positive mode; targeted on the industry players to work efficiently and systematically in handling the seen and unforeseen building defects. However, Millions of Ringgit still need to be spent yearly and annually to tackle the rigorous building's defects delinquent.

Additionally, a more statistical study revealed that in 2011, the Malaysian Government (G.O.M.) spent RM514 Million to rectify defects to 5,555 blocks of classrooms within the 2,202 schools around the country. In 2017, the state Government of Johore allocated RM25 Million per year to maintain and repair the building defects of 73 P.D.K. *(Pemulihan Dalam Komuniti)*; Community Rehabilitation Centers located scattered around the state. In a recent report (April 2019) Penang State Administration spent as high as RM173 Million to maintain and undertake rectification works on building defects for the old State Government's public housing (see Table 1.1). In 2006, the defect costs were about Australian $1 Billion per annum in considering the annual turnover of the state of Victoria residential construction industry was Australian S18 Billion (Mills et al., 2009). That represents a massive 5.5% of the construction of the annual defect cost solely allocated to do the

rectification works, and it is a big issue. Recently, in 2019, Property Management Company in Australia revealed that new homeowners had been slugged a staggering A$10.5 billion in repair costs over the past decade as poor construction standards have left them battling leaks, cracks and other problems.

Table 1. 1 Summary table depicted selected samples cases of LOCAL building defects problem

No.	Building	Location	Defects Problem	Build	Leakage event/s	Cost of defects correction (RM)
1	Parliament Building	Kuala Lumpur	Roof leakage	1967	2005 and 2009	10M
2	KLIA2 new terminal	Sepang, Selangor	Various defects	2010-2014	2016	270M
3	PGA police housing	Ulu Kinta, Perak	Mainly roof leakages	1967-19812	2019-current	Various 1M-5M
4	Teachers housing	P.Pinang, Kedah	Various defects	2000	2010	Various 1M-5M
5	MIMOS HQ	Bukit Jalil, KL	Flat roof leaking defects	2000	2005	30K
6	(Community Rehab Ctr)	Johor State	Various defects	1980s-2000s	2011	25M
7	School buildings	Scaterred in Malaysia	Various defects	1980s-2000s	2011	514M
8	Penang public housing	P Pinang	Various defects	1990s	2019	173M

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 (which is resource-intensive) or replace (which is even more resource-intensive) this square footage. Operation and maintenance costs represent 60% to 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 that usually occur in the school buildings over 100 years;

for example, in the State of Perak, Malaysia are pretty similar to other heritage buildings in Malaysia (Alauddin et al., 2016). Alternatively, (Snyder, 1984) look at the most molecular level are building materials and also building components such as stairs, windows, and air-conditioning ducts contributing to building problems not only to its age. Thus, this where architectural research can play its role. Instead, the interest for architectural research is not in the properties of the materials or the components as such but rather in how they can be used in buildings. The joyous amalgamation of architectural research and building technical knowledge can be a good combination of a method to solve the unique problem gap due to the seen and unseen building defects problem (R. Talib et al., 2015). With 13 separated factors formalised as the factors in creating the latent and non-latent defects shown in Figure 1.1, the GAP among the actions in noticing the building defects is the primary research objective morphology laid down within the **research questions** (see Sub-Chapter 1.6.1).

1.2 Why Latent Defect matters?

In general term, a latent defect is a fault in a property that could not have reasonably been discovered through an inspection before completion and ultimately sale (TR Practical Law, 2019). (Karavitis, 2018) translated latent defect was defined as having the meaning of "… a concealed flaw… a defect that would not be discovered following the nature of inspection that the defendant might reasonably anticipate the article would be subjected to". This could be due to the design, workmanship or materials used during construction. Examples of material latent defects include foundation instabilities or crack, leaks in the ceiling or roof or plumbing issues, i.e. water leakage in the basement or wet areas. Typically, liability for latent defects will

continue for five years after the completion certificate is issued and common law a further three years after that (Attov, 2019; Opfer, 1997)

(*Defects in Construction - Designing Buildings Wiki*, 2020) interpreting defects as the aspects of the works that are not following the contract. Defects may occur because of design deficiencies, material deficiencies, specification problems and workmanship deficiencies. Defects can be 'patent' or 'latent'. Patent defects are those which can be discovered by reasonable inspection. Latent defects cannot be discovered by reasonable inspection, for example, problems with foundations that may not become apparent for several years after completion when settlement causes cracking in the building. When a latent defect becomes apparent, it becomes patent rather than latent. This sub-chapter write-up considers a defect that appears just after the contractual Defects Liability Period (D.L.P.) has expired and argues that the distinction does matter, but perhaps not as much as the significant construction players might think.

However, latent defects have a significant effect on the interiority part of the building (Chong & Low, 2006). If the latent defects were not handled correctly by the parties involved, the mess caused by latent defects would negatively damage the interior space, at least from the contractual point of view (Ahmad Rashid et al., 2014). The case for researching latent defects on the interior spaces specifically for public buildings (in this case in Malaysia) has not been done extensively previously by any academician in Malaysia or from academicians from other parts of the world. Thus, for this research to start with, as a starting point, the initial search for latent defect data and why the cause is essential has been identified, especially during the Qualitative Method (Q.L.) data collection phase. On conjectural hypothetical arguments of a

hypothetical situation revealing that latent defects on the INTERIOR SPACES might matter as it constructs a diversion of funds to repair instead or eat up a significance of the proportion of cost fixing the latent defect.

To keep the affected Interior Space with free-latent defects symptom, governing the ignorance insolence among the construction players on building control system and Building Acts must be done. For example, they are having complied with the role of the PSP (under the Street, Drainage and Building [S.D.B.] Act; Architects Act; and Law on Tort and assuming a reasonable standard of professionalism, the building is technically and legally fit for its purpose insofar as complying with the minimum standards of UBBL (Uniform Building [Amendment] By-Laws) and hence the objective of the S.D.B. Act with free latent defects at least to its interior. The aim is on how the architects or the PSP approached the compliance and certifications in dealing with the workmanship. It is clearly stated that "[in] the architect's certified declaration to the UBBL, Clause 53 touches on building materials so that latent defects can be able to get rid-off" (*Quality Workmanship — a Balancing Act of Safety, Standards and Liabilities | The Edge Markets,* n.d.).

1.2.1 Examples of typical Latent Defects

Latent defects are potential invisible faults that are not been identified through general inspection. Those are defects and damages caused by improper design, poor workmanship, or construction material problem. Latent defects are opposite to apparent patent defect. It could only be found after several years of occupancy or long after the Defects Liability Period (D.L.P.) warranty has expired, even with good care (Wordley, 1991). Here are some typical latent defect example cases for reference (see also Table 1.2) –

a) Improper Design Problem –

Inappropriate construction material was specified during the building design stage. For example, cementitious waterproofing system was specified at the rooftop where the area has direct exposure to extreme weather condition. Under such condition, the material would experience cyclical thermal contraction and expansion. However, cementitious waterproofing material is weak in withstanding the thermal movements due to the low elasticity. Thus, the waterproofing layer would fatigue and crack after the repeating process of thermal contraction and expansion. Subsequently, the waterproofing layer would fail to perform due to crack development.

- Improper sizing of the rainwater downpipe could also lead to water leakage on the rooftop. The undersized rainwater downpipe allowed a limited volume of the rainwater to be discharged from rooftop. The high volume of rainwater during heavy rainfall would create the gutter overflowing and cause water leakage problem.

b) Poor Workmanship Problem –

- Poor foundation bearing strength which due to the unsatisfactory workmanship could lead to building settlement and subsequently cause the building cracks. Contractor shall ensure proper workmanship during the piling process. All piling shall be driven to set or bedrock to ensure stability, unless the piles were designed as friction piles.

- Unprofessional tile installation always leads to tile pop-up due to the hollowness exists in the binder mortar layer. The defects could be caused by improper application or not applying the bonding agents between the mortar layer of the tiles and floor.

c) Construction Material Problem -

- Construction material problems could be caused by incorrect manufacturers' declaration or improper contractors' "cost-saving" exercises. Substandard materials were supplied to fulfil their obligation with the lowest possible costs. For example, tiles were found cracked over time after they have been laid. After inspection, it was proved that the problem was not caused by workmanship problem, as there was no existence of hollowness. Therefore, this is mainly due to the poor quality of the tiles.

- The concrete slab was found cracked after the building has been long occupied. It is suspected due to overloading or the substandard of concrete was supplied. After conducting the concrete core test, it was proven that the casted concrete has not achieved the minimum required strength and thus causing it to crack over time.

Table 1. 2 Initial table summarize TYPICAL latent Defects general causal factors

TYPICAL OF LATENT DEFECTS (PHYSICAL)	LATENT DEFECTS EXISTANCE CAUSAL FACTORS					* Based on obsevation excersices
	Improper design	Poor workmanship	Const. material problem	Wrong specification	Maintenance issues	
Wrong waterproffing type at roof top-solid or liquid.		■	■	■		Found after DLP
RWDP size not right.	■					Found thru general inspection
Poor foundation design and build.	■	■				Found after DLP
Floor tile installation.		■				Found thru general inspection
Concrete slab cracked (flat roof) - low grade.			■	■		Affected conctruction contract.
Ceiling (roof) cracks/ leaks-due to rusty metal roof.		■			■	Found after DLP
Plumbing leakages.	■	■			■	Found after DLP
Wet area not properly waterproofed.		■	■			Found after DLP

1.2.2 Hidden defects challenge –Iceberg effect

Latent or unseen defects, also known as hidden defects, become a significant problem within the construction industry. It can be portrayed as an iceberg floating on

the sea where only the top part can be seen, which means that only the non-latent or non-hidden defects can be seen physically or noticeable from the naked eyes (see Plate 1.1). All the latent and unseen defects cannot be seen and hidden until a specific period. Things got much worse when the building defects only "pop" out right after the Warranty or Defect Liability Period (D.L.P.) is over. In Malaysia, D.L.P. lasts for merely 18 months from delivering the property key.

So far, from the L.R. process, less amount of research found locally or internationally focusing on the impact of the building's latent defects, particularly affecting the Interior Space, can be found. Instantaneously, latent defects are hiding from the actual scenario and affecting the Interior Space where the building's internal space locates all the treasured asset and can also determine the high or low value of the structure.

Plate 1. 1 Iceberg analogy on building defects

1.3 Affected 'INTERIOR SPACE' due to Defects –Require Creativity Research

The structures and shells of buildings create INTERIOR SPACES, and people spend most of their lives indoors compared to outdoors (Ching, 2018). The space located right within a structure or in the internal part of the building components is vital and acts as a foundation for the entire interior design *pochê* plan (*7 Elements of Interior Design - Launchpad Academy*, 2015). Being right in the middle of the building structure, **INTERIOR SPACE** faces a tremendous challenge in tackling building defects. The defects can be traced starting from the computer drafting screen followed by during the construction period. The figural graphic developed by the researcher as in Figure 1.1 shows clearly in a sectional format the relationship between the affected internal spaces concerning all sort of defects types potentially to have occurred. There are 15 types of potentially physical building defects possible giving a negative impact to the INTERIOR SPACE ranging from the obvious B.L.S. to the structural defects originating from the tree's root. Other than that, there are five identified main factors helping in determining having the building defects to be occurred right at the thin fringe of the internal space (see Figure 1.1 again).

From the rigorous literature research done, it seems like none of the indexed journals originated locally and internationally been written solely focusing on the building defects concerning giving negative impact to the important internal space specifically. This is where this write-up becomes the first significant research dealing with the said issue and definitely will give an outstanding contribution to the body of knowledge within the topic range. With the diverse defects components located outside the interior box, as seen in Figure 1.1, it is somehow that the way the figure

has been drawn leading the research become more creative, and creativity is essential in doing any research.

Effective functional Interior Space ensures optimal use of floor area without wasted space; often make full use of its circulation layout, have unnecessary storage and other wasteful activities, and be well protected from building defect factors, especially from B.L.S or B.L.D. A well-considered and designed space plan will mean nothing if it allows building defects to happen, thus hindering the internal space from being deserved the best use of the floor area (Hofman Architects, 2019).

However, built without today's advanced technology, many modernist homes, i.e. Corbusier's Villa Savoye or Mies Van Der Rohe's Farnworth house, suffer from leaky roofs at best and structural instability at worst, much to the dismay of the people who commissioned them. Unfortunately, these aesthetic goals led to not-so-realistic interiority living situations, and today many of these houses function not as residences but as museums honouring visionary design (Allen, 2016).

(*Award: Drywall Waste Block, a Green CMU | Architect Magazine*, 2019) stated that it is well known that people generally spend more than 90% of their lives indoors, yet information on how design can impact the quality of life just recently begun to receive significant scientific research attention. In the late 1990s, some researchers began to link stress levels to architectural dimensions. Lastly but not least, according to the survey conducted from late September 1992 through September 1994 by the University of Maryland's Survey Research Center, Americans spend 87% of their time indoors and an additional 6% in an enclosed vehicle (on average). Given the intense interest in the architectural community on internal quality space and the relation to the high and well-building standard, people probably heard someone

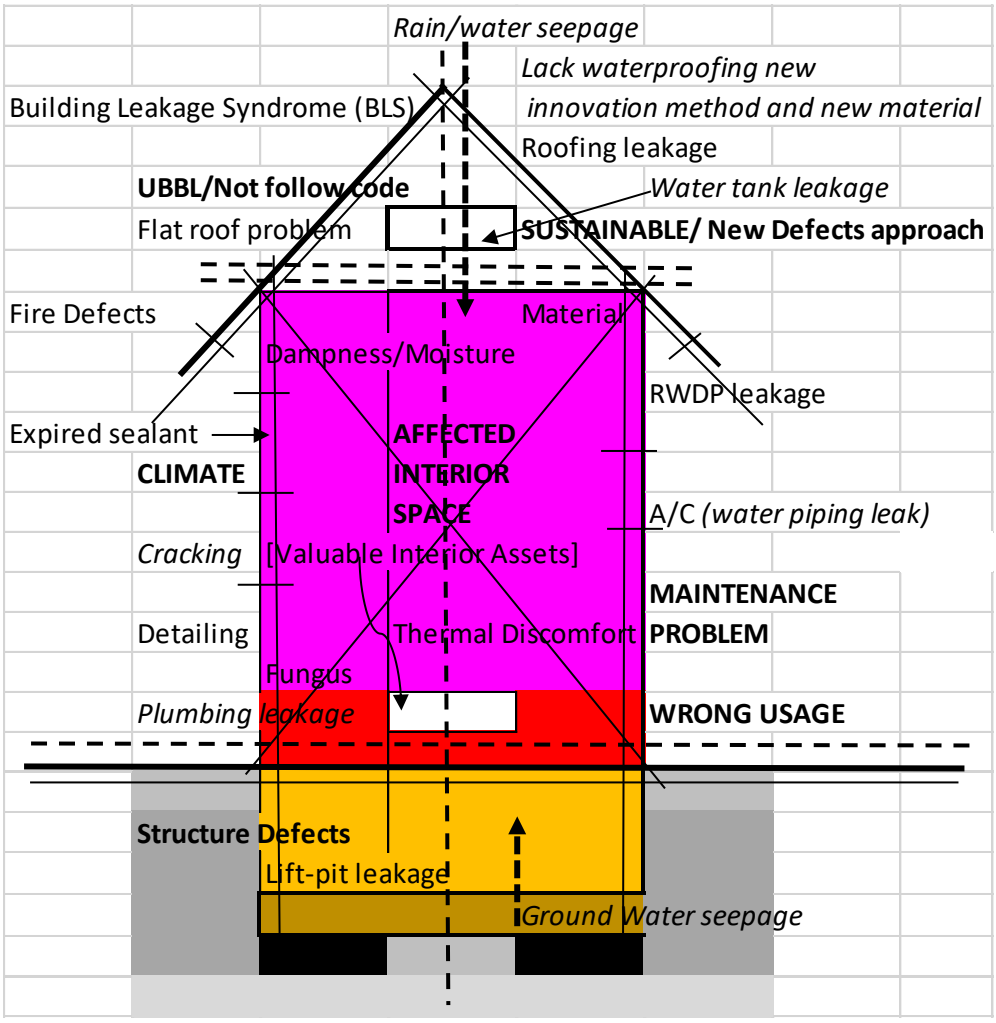

Figure 1. 1 Creative Research: Challenge being centrally located- Interior versus Defects

mentioned that the general public spends 90% of their time indoors. Usually, this is followed by some assertion during the COVIC-19 pandemic period that unquestionable people now spend 100% of their time indoors. Thus, we need to make serious on our products, materials, and interior spaces better and healthier. It is a new normal that we always get reminders not to get outside a little more often and stay put inside even after the post-COVIC-19 pandemic era. Thus, this is where at this COVIC-19 (or post-COVIC-19) era, this research made very important in unprecedented research worldwide. The importance and challenges of a real-time pandemic or non-

pandemic research and the importance of a 'built environmental' scientist workforce is all highlighted by this epic pandemic.

1.3.1 The Affected 'INTERIOR SPACE' and the Defects

Various factors can articulate the capabilities to cause building defects to happen. Adopting an evidence-based approach to identify defects, the research tends to focus on various types of defects that can be found inside the buildings. Figure 1.2 shows the relationship between the three layers adjoining the affected **INTERIOR SPACE** and impacting the internal core. The first layer surrounding the internal space is the highlight of the research; the building failures. The defects surrounding the internal space harming the internal part of the buildings. The defects can be traced chiefly from the water leakage, which is the most shared defect problem within the building industry.

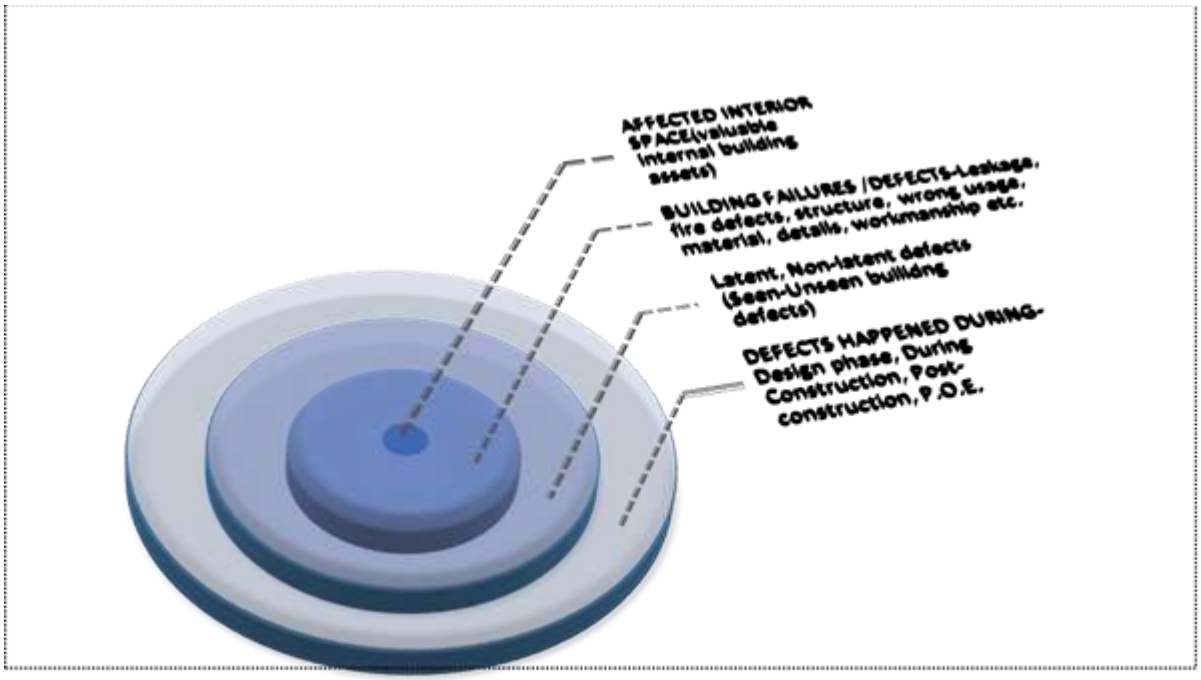

Figure 1. 2 The CORE – Affected precious internal space due to defects

The L.R. revealed that other defects problem also comes from the failure of the building structure, fire factors, wrong usage of the spaces, usage of unsuitable building materials, improper construction details that lead to non-functional aspects, and non-skill labour. Even though many identified defect causes, there are only two categories of defects found; the latent and the other one, non-latent. The most problematic one among the cause of the defects is the latent defects which are the type of building defects that cannot be seen from the naked eyes.

As shown on the graphic, the last layer is the stage of defects tracing when the defects happened. In a simple scenario, defects can be traced from the pre-construction phase to the design stage. Most of the non-latent defects can be found during the construction period, but a particular type of defects is hidden during construction and appear during the post-construction period. Additionally, (Rabinowitz, 1989) stressed that Post Occupancy Evaluation (P.O.E.) might also help trace building defects, possibly the latent defects, and undoubtedly improve the standard of the building by refining the design brief and programme. (Roslan Talib et al., 2015) indicated that latent defects could be traced in more numbers not only within the wet and warm tropical region like Malaysia with the high collection of rainwater 'cm' but also in the United Kingdom, such as in Birmingham (where most of the U.K. cases for this study came from here) with mild winters and temperate summers with less rain. The tracing can be done if enough data on latent defects accumulated within the two regions is done extensively and correctly. Lastly, this selected Quotation on 'INTERIOR SPACE' as below seems relevant to the research.

"In most cases, the most important thing in architecture is what happens in <u>the</u> <u>interior</u>"

(Kramer & Mayhofer, 2017) *wrote on Javier Larraz Arquitectos's Shelter home for the Homeless, E project in Spain, built in 2010.*

1.4 Defects and Public Buildings

Definition of a public building from the Collins English Dictionary (API, 2019) stated that it means a building that belongs to a town or state and is used by the public. Public buildings are any type of building accessible to the public and is funded from public sources. Typically, public buildings are funded through tax money by the U.S. Government or state or local Governments. All types of Government offices are considered public buildings.

(Department for Communities and Local Government, 2015), points out that E.U. countries define 'public buildings' in several different ways. The Czech Republic defines the public as; all buildings that are not apartments or are non-residential. For Finland, those buildings provide public services. In France, a building is occupied by a Governmental body. The document proposes that in the U.K., a narrow definition should be adopted a building that is: 'occupied by a public authority and frequently visited by the public''. It defines 'frequently visited by the public' as; 'daily attendance during days of operation by people for purposes unrelated to their residence, employment, education or training. This means, for example, that a school used only as a school is not a public building because it is not daily attended by people who are neither staff nor pupils. However, a school that is also used daily for community functions is a public building.

'Public authority is defined in the Freedom of Information Act (FOIA) (INSPECTOR GENERAL (OIG) FOIA, 2019) as anybody which, any other person who, or the holder of any office which is listed in Schedule 1 of the Act, (Government departments, legislative bodies, the armed forces, and so on). Alternatively, it is designated by the Secretary of State under Section 5 of the Act (because they appear

to be carrying out functions of a public nature or are contracted to provide a service which is a function of a public authority) or a publicly owned company as defined by Section 6 (such as a company wholly owned by the Crown).

The Building Regulations (Designing Buildings Ltd., 2019) define public buildings as building consisting of or containing a theatre, public library, hall or another place of public resort; a school or other educational establishment not exempted from the operation of building regulations under section 4 (1) (a) of the Act (7); or a place of public worship. However, a building is not to be treated as a place of the public resort because it is, or it contains, a shop, storehouse, or warehouse, or is a dwelling to which members of the public are occasionally admitted.

Case study context revealed that among the most notable problem arises on specific public building is on the James R. Thompson Center in Chicago, Illinois, USA. Gov. J.B. Pritzker officially put the James R. Thompson Center on the market in May 2021, announcing a request for suggestions for the sale of the downtown State Government building that state officials concede could need more than US$500 million in maintenances. The sale of the Thompson Center has been discussed for nearly 20 years and selling the property provides a unique opportunity to maximize taxpayer savings, create thousands of union jobs, generate millions of dollars in real estate taxes to benefit the City of Chicago and spur economic development. Designed by starchitect, Helmut Jahn, the Thompson Center won praise for its innovative structure. But it has been equally well known for state employees' grievances over its state of disrepair, including temperature problems, leaky ceilings, and cockroaches. The odors seeping up the open atrium from the lower-level food court to upper-floor offices have also been a regular gripe (Hinton, 2021).

Conversely, it is estimated that the Government of Malaysia (G.O.M.) owned public building value between Five to Seven Trillion Ringgit. However, the G.O.M. has also spent Millions of Ringgit to continuously build new public structures, for example, schools, emergency clinics and government workplaces to guarantee all that administrations by the Government can be provided to people in general. As a quickly emerging nation and is moving toward the situation with an advanced country by the approaching year 2025 (the initial year is 2020), the G.O.M. indirectly spent a significant budget allocation to guarantee the internal and external condition of the Government-owned edifices are at their finest. As mentioned, a total of financial provision held to perform maintenance on these buildings is put aside to be in the best condition.

1.5 Research Intentions and the GAP

Among the main objective of this research is to sort out the preliminary investigation of defects and minimise the cost of construction and improve the quality of materials used in the construction. According to (JTSB, 2014) bristly estimates, construction defect reparative works can account for between 2% and 20% of a typical project's contract amount. Avoid that costly outcome by assessing the quality of the workmanship and identifying errors before they lead to significant problems and rework. The occurrence of construction defects will lead to lower customer satisfaction and a decrease in the progress reputation in the building market, private or public sectors. Building representative from the project clients with construction-oriented needs to be placed within the construction process to improve the quality and service to the end-users, especially for the Government (G.O.M.) client for civic buildings.

The most primary reason is shoddy workmanship as the applicator does not follow the instructions given in specifics. Thus, the contractors are responsible for the occurrence of defects. A comprehensive inspection of work is necessary for a building at a particular time interval throughout the life phases of a building to avoid shoddy workmanship. For example, the lack of maintenance or incorrect maintenance with shoddy rectification workmanship during the post-construction phase will transcend to reduce the life of the building and also reduces the practical life of the materials far lower than it should be (Roslan Talib, Ahmad, & Sulieman, 2014). Consequently, this succeeding stage of the research is to concentrate on defects that occur in construction projects after the hand-over of the project. Defect analysis can be part and parcel of the safety task because the life of the building and safety will always depend on the strength and durability of the components of the building (internally or externally), and if the components are defect-free, ultimately, we will get the best service life and safety.

Glover (2002), Subhi, Dinesh, & Resmi (2017) and National Building Agency (1979) stated that research shows that due to construction defects, the cost of construction has been increased, and the life of the internal components and structures of the buildings typically decreased. The practical reason for the defects is commonly found everywhere (internally or externally), as mentioned before, i.e., poor workmanship, improper design, an essential quality of materials, lack of supervision methods, wrong construction methods, or lack of comprehensive inspection after construction, etc.

After doing an intensive review on the rebellious subject, the researcher had inevitably come up with the graphic (Plate 1.2) to summarise how to locate the

unbridgeable GAP to be anxiously studied. First, the significant research intention categories are somehow related to each other. These fundamental defects must be adequately documented and systematically in a correct and proper order to intentionally build a reference guide for the related defects to be used appropriately to rectify the ethical problem at any stage of the process. However, somehow, it was improperly measured to reluctantly not be able to produce the systematic identified defect issues to fill-out the defects GAP loopholes. The issues can be used as an astringent guideline derived from the peculiar defects triggering factor facts as indicated. Thus, hoping to solve the subject matter problems once and for all satisfactorily.

Plate 1. 2 Identified latent defects (the CORE) triggering factors (the outside part) in building construction scenario minding the GAP facts

Next, at this point, the gap's loophole also allegedly happened when no critical linkages among the four distinct phases of the construction period. It started from the