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# Building Condition Assessment Using Condition Survey Protocol Matrix: A Case of School Building

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**Abstract:** The school buildings condition is an important factor in influencing school learning environment. This study aims to contribute in establishing the actual condition of primary school buildings in Sarawak, Malaysia. It focuses on the relation of school's age and building condition. The primary data is collected via building condition survey from 24 primary schools using Condition Survey Protocol (CSP) 1 Matrix and analyze via Statistical Package for Social Sciences. The school age is taken up as main parameter towards the analysis of number of defects, total marks and overall building condition. The analysis carried out found that 4,725 defects have been identified and the overall rating for all school is 9.71 which is at the fair condition. The findings proved that building age is closely related to buildings condition and it supported the prevalence theory that 'the aging building has more defect than the new one'. This indicates that the maintenance mentality is still in traditional mode and remains unchanged. The finding could assist relevant parties to take appropriate action in improving school facilities condition.

**Key words:** Building condition, CSP1 Matrix, assessment, school, Malaysia

## INTRODUCTION

Building is a major asset for all types of organizations including the public sector. The important of assets is as important as human, financial and information resources which can contribute to the success of an organization when it is managed effectively and efficiently. To maintain the value of an asset, it must be professionally managed. It has been proven that not only huge amount of capital needed to ensure that the assets can be maintained but the assets value also can be increased through a creative and effective asset management. Even so, the maintenance management system in Malaysia is still in need of improvement. Furthermore, the public sector in Malaysia is still developing their awareness on the idea that the building is a precious asset. Typically, an obligation to protect public property including public school in Malaysia have been distributed among several government departments and are often implemented in reactive.

Generally in Malaysia, the evaluation of school buildings has not been formally developed. There is no parameter or system to assess the condition of school building in detail for a certainty whether the school building is providing a conducive learning environment or not. Since, the school building is the main asset in the learning process, information on the current condition of the building is very important to the school managements.

This study focuses on assessing the condition of school buildings which one of the key process in the life cycle of a comprehensive asset management and facilities management. This assessment is important to ensure the assets of the building is capable of supporting a school's core operations which need to operate efficiently and effectively in providing a quality learning environment to the school users. This study discusses the evaluation of school buildings condition based on CSP1 Matrix's assessment and analysis.

**Literature review:** Maintenance of school buildings includes activities to maintain school facilities as to keep it in good condition. In Malaysia, school building maintenance usually were neglected (Yacob, 2005) and there are no sufficient guidelines for this process (Myeda *et al*., 2011). Maintenance work is not only necessary for the aging building. It is needed as to new building as well. New building will not remain constant during its lifetime (Lateef *et al*., 2011).

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Assessment of building condition is therefore needed as one of the proactive steps in managing and maintaining the performance of school facilities.

School is the building that is used for the teaching purposes (Hassanain, 2006) and classrooms are physical spaces that are designed to support face to face teaching and learning activities (Brown and Lippincott, 2003; Temple, 2008). There is significant impact of school building condition on student achievements (Edwards, 1992; Lewis, 2001; Earthman, 2002; Al-Enezi, 2002; Hutchinson, 2003; Mendell and Heath, 2003; Bosch, 2004; Tiburcio and Finch, 2004; Adeogun and Osifila, 2008; Tanner, 2009; Uline and Tschannen-Moran, 2008; Fram, 2010; Syakima *et al*., 2011) because the built environment can influence users' behavior (Rapoport, 1982). Meanwhile, Schneider (2002) stated that physical aspects of school environment can affect teaching and learning, either will help or inhibit the process.

The relationship between school buildings condition with student achievement was explained by Uline and Tschannen-Moran (2008) who asserts that student from school with the better environment showed higher achievement. Schneider (2002) added that school facilities have a direct impact on teaching and learning thus good school facilities can be provided by an efficient maintenance. Besides that characteristic of the occupied space affect the exchange of information and working environment (Omta and van Engelen, 1998; Toker and Gray, 2008). In addition, Sanoff (2002) also stated that the physical condition of schools affect the behaviors and attitudes of both the teachers and students. He stressed that the building and spaces reflect the message of life, activities and social values of users. The features such as color, shape and arrangement are able to help students and teachers to identify clear mental image of the environment (Sanoff, 2002).

Extraction from a report issued by the United States Government Accountability Office (GAO) in March 2011, typically operational and maintenance cost is between 60-80% from the total cost of facility during its lifetime. Besides, the report also revealed that there were weaknesses in assets maintenance activities carried out by the government (GAO, 2011). Based on these reports, it is clear that the inspection of school building is very important to evaluate the condition before it become more serious. This action will reduce the future maintenance cost and it must be done by the experts.

Facilities management and organizational structure has the potential to improve physical performance and condition of the building and system (Lavy, 2008). Therefore, maintenance is required for school buildings to ensure they are safe and able to provide a conducive environment to assist the learning process. Every organization has a different role and maintenance policy because it depends on the amount, system and quality of building design (Yacob, 2005). In Malaysia, there are no policy of maintenance on school buildings or perhaps directly overlooked by the school management (Yacob, 2005).

Josephson and Hammarlund (1999) define the building defects as the non-fulfillment of intended usage requirement. Referring to the definition of Josephson and Hammarlund (1999) and in the context of this research, school defect is referring to physical condition of building and these defects affect the state of school buildings. Defects in the building are the problem faced by most of the building regardless of building construction techniques or age but it depends to the causes and the factors causing the occurrence of defects (Ramly, 2004). Causes of many defects in the building are associated with human factors. Josephson and Hammarlund (1999) states that the defects in the building, others that are caused by technical factors, also caused by human factors such as lack of knowledge, lack of information, lack of motivation and negligence of construction workers. As a result of human factors (which is inevitable) the inspection is to be done in minimizing defects in the building, especially at the time of construction.

## MATERIALS AND METHODS

Data required for the evaluation of school building condition is gathered via building inspection works. Samples of this research focus on public school in Kuching and Sarawak. Data collection and analysis conducted is based on CSP1 Matrix. There are 134 public primary schools in Kuching Division (MOE, 2010) and the sampling criteria used are based on school age which refer to the first building constructed for the school. The age of the school is from 65 to 1 year. This research used two sampling methods which is simple random sampling and stratified sampling. Variable of Selection (VOS) used in the calculation of sample size was the rate of school age. The other consideration is 90% confidence level. In addition, the margin of error is controlled by 15%. The calculation of sample size was using the Simple Random Sampling (SRS) formula. Based on the calculation, 24 sample of school has been selected.

The condition of building component is evaluated using CSP1 Matrix. This protocol requires the information of every defect to be assessed in terms of its condition and priority. All defects identified are assessed and recorded on-site with the evidences (photos and plan tag). The score obtained from the scoring system determine the level of defects/component such as good, fair and dilapidated. Besides, the possible cause of the defects is also identified. This information is recorded in Defect Sheet and then it was transferred to the Schedule of Building Condition (Che-Ani *et al*., 2011).

A summary of finding such as the number of defects, total score and overall building rating are based on CSP1 Matrix. These results are then compared with school age as to associate the relationship between school age and building condition. Comparison is presented in the form of bar charts and tables. The data is statistically analyzed using the Software of Statistical Package for Social Sciences (SPSS).

## RESULTS AND DISCUSSION

Assessment of the physical condition of school building at Kuching Division was conducted on 24 schools. In total, 4,275 defects were identified and the total mark is 45,868. This means that the rating for overall condition of the buildings is 9.71 which at a fair level but close to dilapidated.

**The number of defects based on building levels:** According to Table 1, the highest number of defects recorded is on Ground Level with 3176 defects while the lowest number recorded is on Roof Level with 38 defects. Total defects recorded show that the higher the level of building, the number of defects was decreasing. From the aspect of school age, the highest number of defects recorded by the school over 20 years old is 2838 defects. Highest defects on ground floor recorded by the school are over 20 years old. However for the other levels, the highest number of defects recorded by the schools is between the ages of 11-20 years.

**The number of defects based on field:** There are five field related in this survey. Based on Table 2, the highest defects recorded in the field of architecture by 3180 defects (67.30%) followed by mechanical (691/14.58%), structure (475/6.10%), electrical (250/5.30%) and civil (129/2.73%). School over 20 years accounted for the highest defects in architectural field by 1782 defects (37.71%). The same scenario occurs in other field where the schools older than 20 years recorded the highest number of defects. In addition, the comparison between fields showed a difference between the numbers of defects in architecture with other field, particularly civil.

**The number of defects based on component:** There were 67 major component included in this survey. Table 3 presents the only component that has >100 defects. The highest number of defects found on walls (798) followed by floors (690), doors (629), fittings (575), windows (541) and ceilings (476). These components are the main parts of the building and its cover most of the buildings. Meanwhile, there are some other components (which are not listed in Table 4) that have little number of defects such as fire extinguishers, balcony railing and cabinets.

**The types of defects:** There are 207 types of defects recorded in this survey. Table 4 shows the only types of defects that have >100 defects which can be assumed to be the common building defects. Based on Table 5, there are eleven common defects with cracks as the highest types of defects (16.2%) followed by missing (13.9%),

Table 1: The number of building defects based on schools' age and building levels

| | | The number of defects | | | | | |
|---|---|---|---|---|---|---|---|
| Schools' age | No. of schools | Ground level | Level 1 | Level 2 | Level 3 | Roof level | Total |
| <10 | 2 | 100 | 94 | 95 | 0 | 0 | 289 |
| 11-20 | 5 | 798 | 430 | 288 | 58 | 24 | 1598 |
| >20 | 17 | 2278 | 381 | 138 | 27 | 14 | 2838 |
| Total | 24 | 3176 | 905 | 521 | 85 | 38 | 4725 |

Table 2: The number of defects based on field and buildings' age

| | | The number of defects based on field | | | | | |
|---|---|---|---|---|---|---|---|
| Schools' age | No. of schools | Electrical | Mechanical | Architecture | Civil | Structure | Total |
| <10 | 2 | 14 | 38 | 212 | 1 | 24 | 289 |
| 11-20 | 5 | 77 | 212 | 1186 | 39 | 84 | 1598 |
| >20 | 17 | 159 | 441 | 1782 | 88 | 367 | 2838 |
| Total | 24 | 250 | 691 | 3180 | 129 | 475 | 4725 |

damaged (8.6%), broken (7.0%) and punch (4.6%). Large number of cracks is due to the occurrence in the walls and floor which are major components of a building.

**The relationship between components with sub-components and types of defects:** Independent $\chi^2$-test has been used to measure the correlation of relationship between the components and sub-components. Components is intended consists of doors, floors, walls, windows, ceilings, sanitary facilities, equipment, waste pipes and others. Sub-components consists of frames, ceiling boards, tiles and so on. Based on Table 5, the results of analysis show that the components and sub-components have significant relationships. In addition, the types of defects are also connected with the components. This is proved after the $\chi^2$-test conducted in which a $p<0.05$. In other words in the event of defects in components such as doors, indirectly sub-components such as door leaf and frames also had an impact. At the same time, components also influence the occurrence of defects.

**Differences between schools total defects:** One-way Analysis of Variance (ANOVA) was used to determine whether there are differences between schools and the number of defects involved. Based on Table 6, ANOVA analysis showed significant differences for all schools involved in this assessment. This indicates that the findings reported about the defects distribution statistically hold true and reliable to the existing school building condition.

Table 3: The number of defects based on components

| Components | The number of defects | Percentage |
|---|---|---|
| Aprons | 124 | 2.5 |
| Walls | 798 | 16.2 |
| Fittings | 575 | 11.7 |
| Floors | 690 | 14.0 |
| Drains | 136 | 2.8 |
| Wirings | 141 | 2.9 |
| Doors | 629 | 12.8 |
| Sanitary | 144 | 2.9 |
| Ceilings | 476 | 9.7 |
| Columns | 101 | 2.1 |
| Windows | 541 | 11.0 |

*This table presents the only component that has >100 defects

**Schools age:** To examine the relationship between the school age with building condition, the age of each school was identified and listed in Table 7. Two schools are below 10 years, five schools are between 11-20 years and 17 schools are over 20 years. This indicates that the majority of schools inspected were older than 20 years.

Table 4: The types of defects

| Types of defects | The number of defects | Percentage |
|---|---|---|
| Punch | 230 | 4.6 |
| Missing | 683 | 13.9 |
| Rust | 177 | 3.6 |
| Water spot mark | 101 | 2.0 |
| Dirty | 108 | 2.2 |
| Broken | 346 | 7.0 |
| Decayed | 192 | 3.9 |
| Crack | 798 | 16.2 |
| Damaged | 422 | 8.6 |
| Malfunction | 114 | 2.3 |
| Water spot | 129 | 2.6 |

*This table presents the only types of defects that has >100 defects

Table 5: $\chi^2$-test for sub-components and type of defects

| Variables | p-value |
|---|---|
| Sub-component | 0* |
| Type of defects | 0* |

Table 6: Result of ANOVA test

| Schools | N | Mean | SD | F-value | p-value |
|---|---|---|---|---|---|
| **The number of defects between schools** | | | | | |
| SEK01 | 30 | 6.07 | 2.59 | 23.402 | p<0.05 |
| SEK02 | 181 | 10.46 | 6.80 | | |
| SEK03 | 328 | 9.36 | 6.17 | | |
| SEK04 | 184 | 11.60 | 6.49 | | |
| SEK05 | 163 | 10.36 | 2.91 | | |
| SEK06 | 158 | 11.72 | 3.15 | | |
| SEK07 | 132 | 10.40 | 3.04 | | |
| SEK08 | 260 | 6.10 | 4.79 | | |
| SEK09 | 293 | 8.50 | 6.46 | | |
| SEK10 | 165 | 11.25 | 5.58 | | |
| SEK11 | 365 | 11.64 | 5.49 | | |
| SEK12 | 264 | 11.68 | 5.49 | | |
| SEK13 | 307 | 8.21 | 4.99 | | |
| SEK14 | 223 | 7.64 | 4.93 | | |
| SEK15 | 161 | 7.98 | 5.10 | | |
| SEK16 | 151 | 9.51 | 6.22 | | |
| SEK17 | 229 | 11.26 | 5.60 | | |
| SEK18 | 238 | 9.37 | 6.52 | | |
| SEK19 | 271 | 8.43 | 5.63 | | |
| SEK20 | 107 | 13.25 | 5.51 | | |
| SEK21 | 167 | 8.41 | 5.89 | | |
| SEK22 | 138 | 10.53 | 5.06 | | |
| SEK23 | 89 | 13.23 | 5.09 | | |
| SEK24 | 121 | 12.32 | 6.20 | | |
| Total | 4725 | 9.97 | 5.60 | | |

*Significant at the level of significance 0.05, SD = Standard Deviation

Table 7: Age of schools

| Schools' code | Building age (years) | Schools' code | Building age (years) | Schools' code | Building age (years) | Schools' code | Building age (years) |
|---|---|---|---|---|---|---|---|
| SEK01 | 4 | SEK07 | 22 | SEK13 | 11 | SEK19 | 58 |
| SEK02 | 26 | SEK08 | 7 | SEK14 | 43 | SEK20 | 51 |
| SEK03 | 16 | SEK09 | 15 | SEK15 | 44 | SEK21 | 37 |
| SEK04 | 26 | SEK10 | 36 | SEK16 | 44 | SEK22 | 53 |
| SEK05 | 44 | SEK11 | 14 | SEK17 | 17 | SEK23 | 39 |
| SEK06 | 48 | SEK12 | 44 | SEK18 | 43 | SEK24 | 49 |

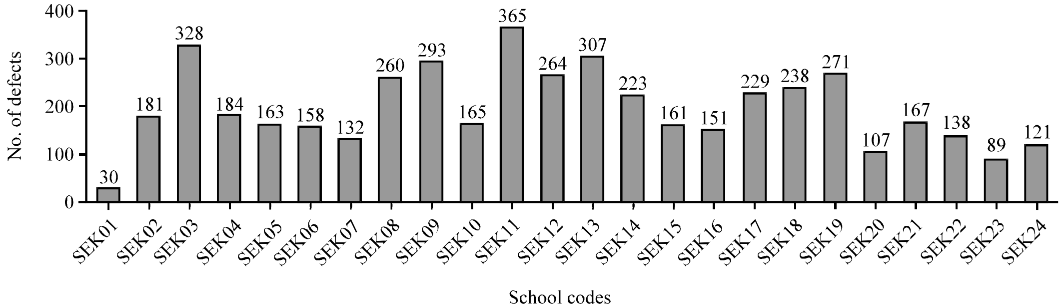


Fig. 1: The number of defects by schools

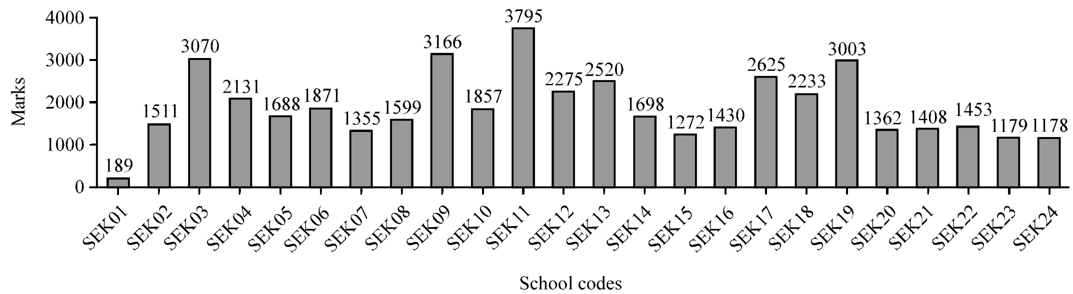


Fig. 2: Total marks by schools

Table 8: The number of schools according to age range compared to the number of defects

| School age (years) | No. of schools | The number of schools according to the number of defects | | | |
|---|---|---|---|---|---|
| | | 0-100 | 100-200 | 200-300 | >300 |
| 1-5 | 1 | 1 | 0 | 0 | 0 |
| 6-10 | 1 | 0 | 0 | 1 | 0 |
| 11-15 | 3 | 0 | 0 | 1 | 2 |
| 16-20 | 2 | 0 | 0 | 1 | 1 |
| >20 | 17 | 1 | 12 | 4 | 0 |
| Total | 24 | 2 | 12 | 7 | 3 |

**The number of defects:** A total of 4,725 defects identified in 24 schools involved in the study. Highest number of defects found is at SEK11 which is 365 defects while the lowest at SEK01 with 30 defects. Figure 1 shows the number of defects by schools.

Table 8 showed the number of school according to age range compared to the number of defects. It is clear that the buildings older than 20 years have a high number of defects with a majority of 12 schools are between 100-200 defects. However, the highest number of defects recorded by the schools in range between 11-20 years (>300). This scenario indicates that the critical age of school is between 11-20 years. Comparatively, school age which is >20 years does not have >300 defects recorded, even though the number of school of >20 years is 17 schools (the highest number of school involved in this study).

Table 9: The number of schools based on age and score

| School's age | No. of schools | No. of schools based on CSP1 Matrix score | | | |
|---|---|---|---|---|---|
| | | 0-1000 | 1001-2000 | 2001-3000 | >3000 |
| 1-5 | 1 | 1 | 0 | 0 | 0 |
| 6-10 | 1 | 0 | 1 | 0 | 0 |
| 11-15 | 3 | 0 | 0 | 1 | 2 |
| 16-20 | 2 | 0 | 0 | 1 | 1 |
| > 20 | 17 | 0 | 13 | 3 | 1 |
| Total | 24 | 1 | 14 | 5 | 4 |

**Total mark:** A total of 45,868 marks recorded from 4,275 defects identified. Figure 2 shows the overall score for each school based on CSP1 Matrix scoring system (the higher the score indicates the worst scenario). The highest score recorded was 3,795 while the lowest score was 189. Meanwhile, only one school recorded score below 1,000 marks and the rest score >1000 marks.

Table 9 shows the number of schools according to age range compared to the scores. Majority of 14 schools scored between 1000-2000 and 13 of 14 schools were over 20 years. The next five schools scored between 2001-3000 marks, four schools scored >3000 marks and only one school scored below 1000 marks. Three of four schools that scored >3000 marks are within 11-20 years. This result demonstrates once again that the schools between 11-20 years have serious building defects.

**Total rating:** Total school condition rating for overall study is 9.71 which in fair condition. Figure 3 shows the

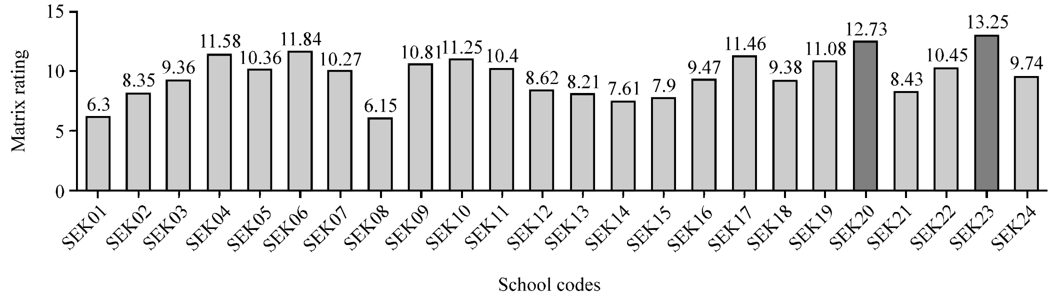


Fig. 3: CSP1 Matrix rating for each school

Table 10: Number of schools based on ages and buildings rating

| School's age (years) | No. of schools | No. of schools based on CSP1 Matrix rating | | |
|---|---|---|---|---|
| | | 1-4 (Good) | 5-12 (Fair) | 13-20 (Dilapidated) |
| 1-5 | 1 | 0 | 1 | 0 |
| 6-10 | 1 | 0 | 1 | 0 |
| 11-15 | 3 | 0 | 3 | 0 |
| 16-20 | 2 | 0 | 2 | 0 |
| >20 | 17 | 0 | 15 | 2 |
| Total | 24 | 0 | 22 | 2 |

Table 11: Relationship between building age with the three aspects

| Theory | No. of defects | Total marks | Building rating |
|---|---|---|---|
| The older school building has more defects | Related | Related | Related |
| The critical school buildings age is between 11-20 years | Related | Related | Not related |

CSP1 Matrix rating for each school. The lowest rating (6.15 fair) which is the best condition was recorded at SEK08 while the highest rating (13.25 dilapidated) at SEK23. This value indicates that the best schools are in fair condition that requires monitoring and the severe school in a situation that requires serious attention. Figure 3 shows the number of schools based on the CSP1 Matrix rating of each school.

The association of ages and building condition show that there are no school in good condition (Table 10). The majority of 22 schools are in fair condition while two schools in dilapidated condition. The two schools which are in dilapidated condition were over 20 years. These figures make it clear that although the number of defects is highest in school between 11-20 years but the defects is at medium condition that requires monitoring and schedule maintenance (bearing in mind it can be in serious condition if no preventive maintenance action taken now). Instead, for the schools over 20 years, even though they have a little number of defects, the defects are serious and require immediate maintenance. This condition indeed supersede the number of defects occurred because the rating is in 'red zone' that requires urgent attention (the defects found involved safety impact if left unattended).

**Association between building's age and condition:** To examine the theory of association between building age and its condition, the relationship between three aspects evaluated (number of damage, total score and building rating) with building age is assessed. Table 6 shows the relationship between school building ages with the three aspects. Based on CSP1 Matrix analysis and Table 11, its shows the relationship between school age theories to school building assessment aspects. Basically, the higher the school age, the more defects occurred and the critical age for building defects occurs is between 11-20 years.

With this finding, it shows that the traditional theory of the older the buildings, the more defects encountered hold true. All three aspects, i.e., number of defects, total marks and building rating, proved that the building age plays a significant factor in predicting the building condition. In other words, researchers can expect these three aspects are highlighted when dealing with the old building. In providing insight to this, the question is post, i.e., how old should a building is to have these high numbers of defects? This is in relation to the finding of this study that reveals the critical age of school buildings is between 11-20 years. This theory considers hold true when two out of three aspect is in relation to this age range, namely number of defects and total marks. Building rating is found not in relation to this critical age theory. Further to discuss, indirectly this study provides a testimony to the CSP1 Matrix itself where it can be used for details analysis, rather than just merely providing overall building rating and provides the list of building condition.

## CONCLUSION

There is growing awareness of public sector in Malaysia as to treat the building as precious asset. Though, the maintenance approach remains in reactive mode. The government had yet to provide the specific guidelines for the management of maintenance and performance measurement of school building. This is of vital importance in supporting the philosophy of Malaysian Total Asset Management Model. In relation to this, building inspection can contribute to its success.

For the building inspection of school buildings, it reveals that the overall school building condition is in fair condition but it close to dilapidated. The age of the schools is suggesting the idea about its actual building condition where the older the school, the higher number of building defects is expected. Apart from this, the critical age of building condition is within the range of 11-20 years old where the number of building defects keeps on increasing. If there is no effective action taken, the defects become worst and will probably put the school condition at risk. This is supported by the findings of the two schools which is found in dilapidated condition are the school that is >20 years.

The implication of this study is going to help the school management to prepare a better plan and prioritize the school maintenance activity. Perhaps it is timely to create a policy that every school need to undergo full building inspection when it reach the first 10 years and it should be carry out subsequently for every 10 years. By using CSP1 Matrix, it helps to prioritize the building defects. The serious defects with the red-coded need to be taken care of first and followed by the yellow-coded. This is also helping the maintenance budget to be spent wisely according to the priority.

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