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Concrete Flat Roof Defects in Equatorial Climates

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Abstract

In recent year, many building in Malaysia have designed for a concrete flat roof rather than traditional pitched roof. There are also buildings that incorporate design slope roofs and flat roofs that keep facility equipment in the flat roof area. However due to hot and humid condition throughout the year in equatorial climate, surface-related defects, damage to the waterproofing membrane and cracks in the roof parapet wall are the common defects of roof construction that require frequent maintenance. This paper seeks to review the common defects of concrete flat roof construction in institutions of higher education buildings in equatorial climates. The research reported was carried out by the building inspection and analysis of 23 case study buildings. Surface profile and the slope of the roof, rainwater drainage, parapet wall and the waterproofing membrane inspected and analyzed. The findings of the inspection indicated that the concrete flat roof slope should be appropriate to the size of a roof and parapet wall dislocation failure is dependent on whether the ends are hinged or fixed. Failure usually leads to tearing of the waterproofing membrane. Proper surface workmanship, modification to the roof parapet wall design and to the selection of

construction materials is suggested. The modes of failure and proposed modification will be of interest to designers and those responsible for the maintenance of flat-roofed buildings in equatorial climates.

Index Terms— condition assessment, building survey, CSP Matrix, concrete flat roof defect

I. INTRODUCTION

In recent years, maintenance work to concrete flat roofs of multi storey buildings has increased significantly. Even a small percentage, the concrete flat roof maintenance need to be due attention. Flat roof will receive direct sunlight throughout the day compared to slope roof. Due to hot and humid condition throughout the year, with relatively high annual average rain intensity in 250 cm (98 inch) yearly and with average temperature is 27 °C (80.6 °F), the problem that mostly associates with the concrete flat roof is a mouldy surface, cracks and waterproofing-related issues. Mouldy surface is due to the water ponding or water stagnant. Concrete flat roof surface with the minimal slope will delay the outflow of water from the roof area. Worse, the water will stagnate if the surface does not levelled and has a puddle in the roof area. Damage of the waterproofing membrane and cracks or dislocations of the parapet wall are the common defects. These become an inconvenience to the occupants and building owners. The objectives of this study are to review the common defects of concrete flat roof surface, rainwater drainage, parapet wall design and waterproofing membrane conditions and formulate possible solutions including the modification of the roof parapet wall design and the selection of construction materials.

II. METHODOLOGY

The construct Data required for the evaluation of concrete flat roof condition obtained by building inspection works. A sample of this research focuses on public university in Bangi, Selangor. Data collection and analysis conducted based on CSP1 Matrix protocol. There are 23 block building which covers Chancellery building and Faculty of Engineering and Build Environment building, and the sampling criteria used are based on building age, which refer to the first building constructed for the university. Building age is range from 1 year to 37 years. Based on the calculation, 23 building have been selected as sample.

The condition of building component is evaluated using a Standard Building Inspection Code published by the Royal Institutional of Surveyors Malaysia (RISM) and Condition Survey Protocol (CSP) 1 Matrix. These code and protocol is a guideline to the Building Surveyor to assess any defect of building based on priority and condition. This matrix has its own scoring system [1] to facilitate the examiner to assess the condition of university building carefully and entirety. 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 also identified. This information recorded in Defect Sheet, and then it was compiled in the Schedule of Building Condition. A summary of finding such as the number of defects, total score and building rating based on CSP1 Matrix is produced.

III. DEFECT OF CONCRETE FLAT ROOF

In most of the previous research, the word "defect" was used to explain imperfection in constructed structure or building. A building defect are considered as shortcoming or failing in performance, function or user need and requirement of a building, and revealed itself in the sub-structure, structure, finishes, services or other facilities affected to the buildings. Through history have been a lot of discussions, tests and studies that have been conducted and concerted interest in building defects. Understanding of the definition and concept of building defects were discussed and highlighted by various researchers. For some people, this means that the weaknesses in the design and construction practices, while to others, it reflects weakness arising from wear and tear. Defects in design and construction are those that are caused because of the construction methods, materials and labor practices are not good. The design plays a major role in determining the condition of the building after completion, mainly in aspects of defects and maintenance. Design influences the performance and physical characteristic of building and its durability to withstand environmental condition, social interfaces such as graffiti and vandalism. Therefore the link between design and maintenance should not only be seen from the point of increasing the repair work or cost involve, but it need to consider also the impact of design on structure and material installed as well as the life cycle of each component of building [2, 10]. Wear and tear is depreciation, reduction or decline the functions or the performance of a building or a service, which arise as a result of ordinary use or equitable. It can also be caused due to the age of the building or services or because the weather is natural and, in fact, a combination of the three. Investigate the causes of defects in the building to see the symptoms that sparked investigations, the location of the symptoms and materials involved [3].

While studies on the concrete flat roof has been researched by several authors. On flat roofs, not only the thermal resistance of the roof section, but also the light reflectance of outside surface materials affected the thermal performance. Outside surface materials with very high light reflectance reduced heat gain in summer considerably [4]. Pounding water-related research has been done by [5]. Common defects of concrete flat roof can be classified into three main categories: surface-related defects, waterproofing defects and cracking on the surface and the parapet wall.

A. Surface-related defects

There are a number of defects that can be grouped in this category. Moldy surface, pounding water, low gradient at the surface, the rough and uneven surfaces are defects that often occur in this category. Moldy surface frequently happen in areas with a high water content or surface contact with moisture in long period. Rainwater drainage

system failures either in the flat roof or parapet walls is cause stagnant water. Dust, dirt and wild plants that live in the flat roof will cause clogged roof drainage, especially during the rainy season. Water retention in the long term will lead to a flat roof surfaces become wet and moldy.

The slope of a flat roof also plays an important role in ensuring the flat roofs dry. Refer to the Building Officials and Code Administrators BOCA in the United States requires a minimum roof slope of 1/4 inch per foot or about 2% (BOCA 1999) [6]. The National Roofing Contractors Association (NRCA) recommends positive drainage and suggests criteria for judging proper slope. The criteria are "that there be no ponding water on the roof 48 hours after a rain during your conditions conducive to drying" (NRCA 2001) [7]. Water flow in excess of 48 hours is considered to have failed. While refer to British Standards BS [8], the relevant codes of practice for flat roofs including BS6229 – Flat roofs with continuously supported coverings, BS8217 – Re-inforced bitumen membranes and BS8218 – Mastic asphalt roofing, clearly indicate the requirement to design falls onto flat roofs. In summary, the following criteria's would apply to flat roof designs for rainwater drainage: *'Flat Roof':* Defined as a flat roof with a minimum finished fall of 1:80, *'Completely Flat Roof':* Defined as a flat roof with a fall of less than 1:80 and *'Failed Roof':* Defined as a flat roof with a backfall those results in excessive rainwater ponding.

This failure can be caused by errors in design or construction not in accordance with specifications. Errors during the construction process may also lead to concrete roof surface becomes rough and uneven. Construction of Concrete flat roof should be carefully designed and constructed so that its functions can be maximized and sustained over a long period, especially in equatorial climates.

B. Waterproofing defects

Common damage to the waterproof is when the membrane layer will harden and causes it dislodged from its original position. Direct rays of the sun throughout the day causes this layer to shrink and expand when wetted by rain. Damage damp proof is usually on the connection between layers, on the side that is connected to parapet wall, around rainwater downpipe and also in flat roof drainage. Common damage is like a layer of shrinkage and expansion, rot, peeling and tearing. This damage can be caused during installation workmanship, materials used, daily use, the way of maintenance, weather and normal wear and tear in the long run.

Design and choice of material for roof parapet wall construction is critical to the maintenance of the waterproofing membrane on the roof slab. It can only be rectified by using low expansion insulation materials that match with the environmental or climatic characteristics of a country [9]. For equatorial climates that receive a lot of rainfall throughout the year require waterproof material that can last longer and be able to maintain its function. The purpose of the original flat roof should also be taken into account during the design process. Most flat roofs of buildings not store services and building facility on the original design, but on the needs of residents of the flat roof has been changed. Functional changes of use will result in damage to the waterproof layer designed for the original.

C. Cracks

A typical crack of buildings in Malaysia is of non-structural type i.e. shrinkage cracks, joint cracks, etc. Surface cracks are commonly found on the concrete flat roof and floor screed and normally caused by improper curing process. Joint cracks are commonly seen at the joint of different structural elements such as concrete flat roof / parapet wall and brick wall. The cracks can be the result of relative thermal expansion between the parapet wall and base slab or the outward horizontal expansion of the roof insulation layer. The crack is normally found along the bottom edge of the parapet that the wall was displaced slightly relative to the roof slab. Cracking at corner of parapet wall appear at the junction of two parapet walls which means the dislocation of wall being aggregated at the ends. The cracks are mostly induced by the thermal expansion of the parapet walls. The common causes of such cracks are identified due to the difference thickness of plastering on those structures and insufficient bonding element that holds concrete flat roof to parapet and brick wall. Other area of cracks is around the opening such as for floor trap and water outlet. These kinds of crack can be repaired easily with straight forward methods such as applying repair mortar / putty onto the affected area (for cracks < 3mm) together with suitable wire meshes provided the surface preparation is carried out in proper ways. In some cases, corrosions of steel reinforcement were detected and these incidents indicated that immediate repair was not carried out at early stage. The measurement of crack progress was carried out using crack gauge to ensure no further crack movement prior to the repair works.

IV. CONCLUSION

Flat roof surface must be free from obstruction so that rain water can flow smoothly from the roof area. The slope of the roof must also be in accordance with specifications laid down and can stream water in less than 48 hours. Construction and use of a flat roof must meet the original design and it needs to be maintained so as not to affect the quality of the materials used. Waterproofing materials selection must take into account the durability factor appropriate to the surrounding environment and weather. Flat roof should be well through curing process so that it is not easy to crack during its lifetime. The thickness of the plaster layer should be uniform and good binder should be selected as finishing materials for flat roofs.

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