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A Case Study of Residential Buildings Subjected to Cracking Failures

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Abstract: The purpose of this paper is to present some preliminary findings of residential buildings which subjected to cracks. The study case covered in this paper is to determine the cause of cracking of semi-detached residential houses which initially expected due to a construction project nearby. Several types of buildings and infrastructures were evaluated through the preliminary qualitative forensic assessment for the hypothesis on the cause of the problems on residential buildings. The initial assumption that caused the cracking was due to the nearby construction works. From the inspection it was suggested that the piling work from the construction project does not have an impact that could damage or jeopardize the main structures. It was expected that the failures occurred on the walls and floors of the houses are more reflected due to the soil settlement on the housing area.

Keywords: Residential building, cracking failure, forensic assessment

1. Introduction

Concrete is the most common building materials. However, the biggest disadvantage of concrete, is it is easy to crack, which leads to the decline of the durability of concrete and causes structural damage [1]. The other problems due to the occurrence of crack are water seepage which leads to the corrosion of reinforcement.

Cracks in a building, generally can be classified as superficial or structural cracks. There are a variety of ways that cracking in a building element can constitute. The occurrence of crack can be due to the defect such as structural defects, serviceability defect and/or appearance defect. However, the actual consequence or cause of cracking is unknown until further information is obtained.

Basically, concrete has low tensile strength and any induced tensile stress may cause the concrete to crack [2]. However, the identification of a crack is not simple, but some cracks can be obviously serious judging from its visual appearance which can be a major cause of damage to concrete structures and buildings. The initial assessment through visual inspection is the first step to classify the damage of the structure in doubt.

Physical evidence and scientific method are the important scope of forensic investigation to be considered to reasonably assure any key factors to identify the cause, effects and possible remedy of building defect or failure are included.

In this paper, a study case of the occurrence of cracking in residential buildings is discussed. In this case the evaluation was based on solid information that the team gathered during visual inspection.

2. Background

An investigation was carried out to identify the source of the cracking of new residential buildings (semi-detached single-storey houses) that is located near to a 9-storey apartment building construction project. Investigations in the form of visual inspection and information from the developer and the affected residence were considered in determining the cause of the problem.

The construction project has been started in 2015 and is still ongoing. There are two types of residential building involve in this investigation; semi-detached single-storey houses that were most affected and a single storey terrace house. The semi-detached single-storey houses have been occupied for almost 2 years, whereas the single storey terrace houses were built and occupied for more than 10 years. Complaints concerning the occurrence of the cracking of the semi-detached single-storey houses were made by the residents in August 2017 in which the crack was found to be increasingly significant. The piling works of the construction project were completed in March 2016 for the main building apartment, whereas the piling works involved for a single storey shop lot of the project complete in April 2017.

2.1 Method

Visual inspection and preliminary qualitative forensic assessment were conducted on the surroundings of the apartment construction project which covers Fig. 1:

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(A) Several affected residential properties
(B) Two buildings of electrical substations (TNB 1 and TNB 2)
(C) Infrastructures surrounding the project
(D) Oxidation pump house adjacent to TNB substation 1

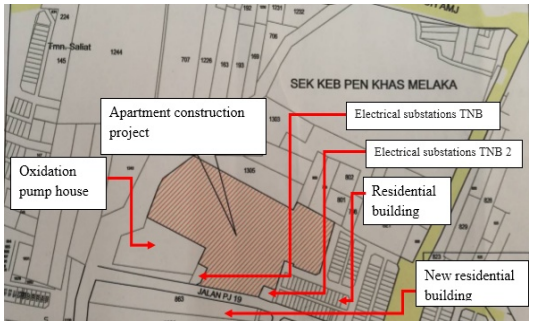


Fig. 1 The location of the investigation

Both TNB 1 and TNB 2 substations are located closest to the ongoing apartment construction project with a distance of about 15m to 20m whereas an oxidation pump house is located next to the TNB 1 substation. The residential house involved in the investigation is located approximately 150m to 200m and a water way is found to the west of these houses. This water way is approximately 50m away from the very end house. To the east is the other row of residential (single storey-houses and the double storey terrace houses) that have long been built.

2.2 Observations

2.2.1 TNB Substations

There are two existing TNB (1 and 2) electrical substations located to the left and right adjacent to the construction project. Visual observation can be only conducted from the outside fence for both buildings. Both of the TNB substations are the closest building to apartment construction projects in this investigation work. From the rear view of the fence, there is no significant cracking can be observed on the outside of the building structure, outer wall, apron floor (outer perimeter) and concrete trench around the building for both TNB substations as shown in Fig. 2.

Fig. 2 Electrical Substation TNB 1 and TNB 2

2.2.2 Infrastructures: Concrete Drains and Road

For the concrete drain located in front of the construction project and adjacent to the semi-detached single storey- houses (Fig. 3), the existing drainage concrete was in satisfactory condition. There was no significant cracking occurred on the concrete channel, its walls and the iron barrier was also not deflected.

Fig. 3 Concrete drain in front of the semi-detached single storey houses

Observation on a small lane between the single storey houses and the construction site shows there was no settlement or cracking effects on the roads and the drains (Figure 4(a)). However, observation on the small lane between the end of semi-detached houses and the double-storey houses shows there was a settlement and significant crack on the side of the semi-detached single storey houses, but there was no settlement and significant crack observed on the old two-story terrace house (Figure 4(b)).

(a) Construction site-single storey houses

(b) Between double storey –semi-detached houses

Fig. 4 Condition of infrastructures

2.2.3 Oxidation Pump House and Oxidation Pond

There was a significant settlement about 150mm observed on the apron and stairs of the oxidation pump house (Figure 5). The pump house and the oxidation pond were both using the old system and were built before the project started. Based on the observation on the settlement, the coloration of the structure it could be expected that the settlement occurred long before the project started. As the Melaka River, which located less than 100 m from the pump house, it could be an indication that the significant settlement may be caused by high water and groundwater levels. From the inspection, it is also expected that the location be more susceptible to the settlement due to the soft ground and water sources. For such location, soil investigation and suitable foundation are necessary to avoid this phenomena.

Fig. 5 Oxidation Pump House

2.2.4 Semidetached single-storey houses

The most affected houses are the semi-detached houses that located in front of the construction project. From the observations, the following were observed;

(i) Car porch floor
The settlement and cracking on the car porch can be seen on the houses (Figure 6). According the resident, the settlement occurred once they occupied the house.

(ii) Settlement on the apron and surrounding column outside of the houses (Figure 7)

(iii) Living room floor (Figure 8)

(iv) Concrete flat roof at the car porch (Figure 9)
The cracking can be seen as the results of rainwater penetration.

(v) Wall at car porch
The brick wall cracked horizontally near the floor level (Figure 10) and the crack width is 7mm which can be classified as moderate [3]. The brick wall is likely to be built without a ground beam and located directly above the floor below it. Therefore, it is not impossible that as the floor experience settlement it will resulted in the brick walls undergoing movement and subsequently cracking.

(vi) Cracking of interior walls
Transverse cracking could be seen mainly on a few sections of the houses (Figure 11). The cracking significantly observed along on the brick wall and the beam intersection, which was expected due to the movement of the building structures, excessive vibration shrinkage / expansion ratio between the different materials (brick, concrete and mortar plaster). However, there is no failure observed in the main building structures.

(vii) Single-storey terrace house
A single-storey terrace house has been investigated and according to the resident the cracking on the brick walls occurred during the piling work on the construction project. However, most of the cracking is no longer noticeable as the walls have been repainted and during the investigation the cracking can be only observed on the kitchen wall (Figure 12)

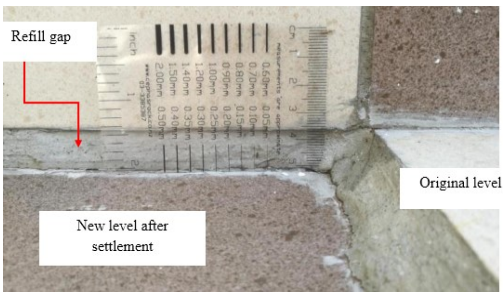


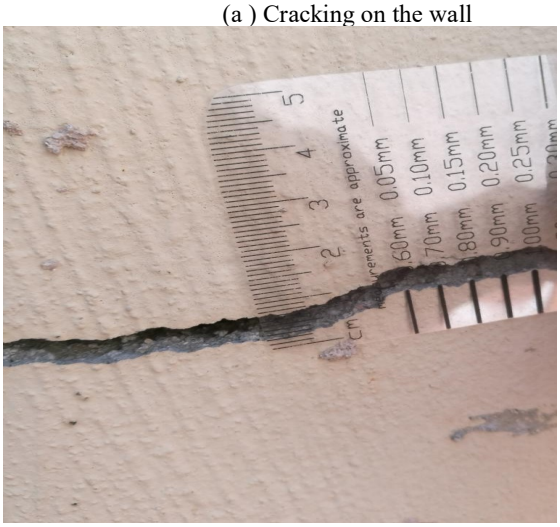
Fig. 6 Car-porch area

Fig 7 Surrounding the house area

Fig. 8 Concrete floor at living room area

Fig. 9 Water penetration

(a) Cracking on the wall



(b) 7mm crack on the wall

Fig. 10 Cracking on brick wall frame at the car-porch floor

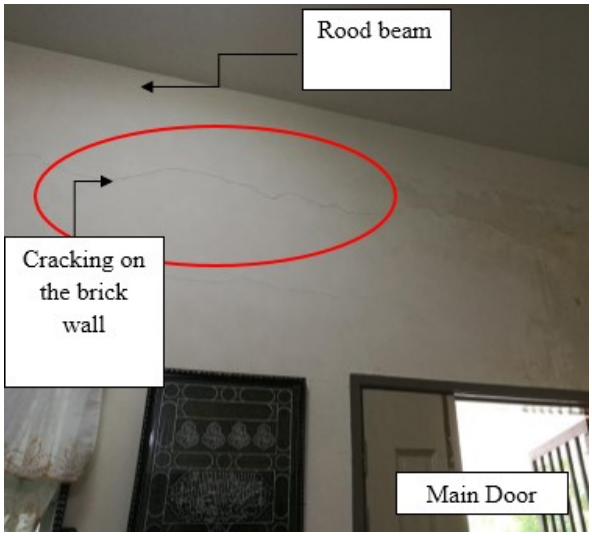


Fig 11 Cracking on brick wall

Fig 12 Cracking on the wall finishing

3. Conclusion

Based on the inspection carried out on buildings and infrastructures surrounding the construction project and semi-detached houses the following concluding remarks can be made:

1. There is no significant fracture / damage as a result of piling work on infrastructure surrounding the construction projects of apartments such as concrete drains and roads near the construction project.
2. The two existing TNB substations are the closest building to the construction projects not showing significant cracking of walls, floor / drain around the buildings. This suggests that piling work of the construction projects has no effect that could damage the structural and non-structural parts of the two TNB substations.
3. The cracking pattern on the semi-detached houses was quite uniform contrast to the cracking pattern occurring in the single-storey terrace houses. Furthermore, there were no cracking or damage could be observed for elements such as beams and columns. This suggests that the piling work from the construction project does not have an impact that could damage or jeopardize the main structures. It was expected that the failures occurred on the walls and floors of the houses are more reflected due to the soil settlement in the housing area.
4. The same settlement phenomenon can be observed has occurred in the oxidation pump house. Based on the conditions and its large settlement indicate that the phenomenon has occurred long before the project started.

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