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Original Article

Basement Construction Success Prevents Cracked Heritage Buildings

Nusa Setiani Triastuti

Faculty of Engineering, Krisnadwipayana University, Jakarta, Indonesia

Corresponding Author : nusasetiani@unkris.ac.id

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Abstract *- This research could be used as a reference for the young engineer for projects in the city center around the world with dense old, heritage buildings around it. The building had 27 floors, 3 basement floors with -1.0 m of groundwater, and a 5 m distance from three heritage buildings. This research was a continuous observation to determine the condition of groundwater during dewatering. The groundwater was recharged until early the groundwater level and monitored during dewatering with simple, practical groundwater maintenance and protection of the environment was carried out by isolation method with basement diaphragm walls. Gap research: 3 basement floor construction methods with maintained groundwater stability were successful even though they were close to a heritage building environment with a shallow foundation, -1.0 m groundwater, narrow land, and risk of collapse. Objective: proper construction methods protected heritage and old buildings with zero accidents and no cracks. Novelty: lowered groundwater from -1.0 m to -15m on 3 basement floors without any cracks at the Cultural Heritage building, which had a shallow foundation. The research anticipated five potential problems so there were no cracks and zero accidents. The conclusion of heritage buildings' success with simple methods did not occur deformation, cracks and zero accidents.*

Keywords *- Dewatering, Recharge, Stability, Environment isolation, Detection of cracked.*

1. Introduction

This research could be used as a reference for projects in the city center worldwide with dense building heritage or old buildings around it and traffic jams. The building has 27 floors, 3 basement floors with -1.0 m of groundwater, and a 5 m distance from three heritage buildings. The case study methodology was continuous observation; if groundwater was reduced drastically, then recharged until the early groundwater level was isolated by diaphragm walls. Researchers suggest groundwater should be as before so that it is recharged outside the basement if it drops. Proper construction method protects heritage buildings (Figures 1b,1c, 1d); old buildings succeed with zero accidents and no cracks. The resulting novelty: lowered groundwater from -1.0 m to -15m in a 3-story basement without any cracks. The researcher anticipates five potential problems so there are no cracks and zero accidents. The conclusion of heritage buildings, the old buildings did not experience deformation and had zero accidents.

Heritage buildings had to be preserved as history tourism. Original heritage buildings may only be painted and cleaned. The heritage building should not be cracked, even if there are thin cracks; heritage buildings should be without putty or plaster. (Triastuti, N.S 2017)

Three heritage buildings did not fail because installing the trench reduced vibrations. Prevention was carried out so that heritage buildings did not collapse by monitoring and anticipating the construction (Triastuti, N.S 2021). The foundation of cultural heritage buildings and old buildings uses shallow foundations. Simple control, practical, but can prevent cracking and zero accidents.

The success of the design and deep excavation construction begins with the detail-planned and closely supervised investigation under construction, including field and laboratory testing (Gue S. S. 1998).

The design of the basement and support system shall follow the appropriate standards, guidelines, and good practices (Gue S. S. 1998). Care and diligence with the full conscience of the construction management team are essential to ensure the success of engineering work, especially deep excavation, which poses a risk not only to this work but also to the work adjacent to the structure (Hammad.A. WA 2019).

The author reveals this scientific paper to be simply applied to professional engineers and academics, analytical examples in the project process. The construction process was simple but impacted, preventing a very big risk for heritage buildings and old buildings so that all heritage buildings did not get cracked deformation. So that the authenticity of the heritage building was retained so that it became a historical heritage and an icon of the central area of the Indonesian government which had to be retained. The original building became a historical tourist attraction for the younger generation and a valuable acknowledgement.

Fig. 1(a), (b), (c), (d) Pink color, 3. Heritage building (source: author document)

This paper greatly impacted heritage buildings with a history for the old and young generations. Hence, according to the original, the integrity was very large for the community and the world, especially those whose ancestors had worked in the building. Researchers who assisted in inspection projects applied these concepts and solutions. Scientific journals had to serve as a reference for engineers to give practical and easy solutions. Besides, the manuscript was a reference for scientists and academics.

2. Research Significance

The Basement Construction research was successful in preventing Crack Heritage Buildings. The Heritage building benefited from history tourism for the old and young generations. Old buildings, heritage buildings, and infrastructure were prevented from cracking at the construction moment of another building as guidance throughout the world's urban areas.

Heritage buildings should be by the original done, not repaired or patched, even though finishing and maintenance was only painting and cleaning. Buildings and infrastructure remained intact without cracks, deformed, or other damage. The principle of the construction process was not to damage buildings and infrastructure; it benefits all urban areas in the world. This research solution is easy to understand, easy to do, and easy to check directly by a field engineer.

3. Methods

Case study basement 3 floors were under a 27-story building very close to the heritage building, with a groundwater level of -1 m, with direct researcher providing input for prevented, observed on-site, and analyzed; field engineers had to give input and solutions to simple, easy to implement and easy to analyzed checking engineers.

The high-potential basement construction was damaged but did not cause cracks or tilting; it managed groundwater and surface water and reduced vibrations with trench digging so that groundwater conditions outside the 3-story basement did not decrease and less vibration. The author immediately saw and monitored the activities of the basement construction, too, that it had secondary data for the 3rd-floor basement, which was under the 27th floor of the building. The author analyzed based on five potential problem-solving steps based on primary and secondary data.

The author analyzed construction methods, and site management provided input on the placement of dewatering points and recharging points, groundwater monitored subsidence outside the basement, and groundwater monitor tools placed to measure movement in heritage buildings. If groundwater drops drastically, it has the potential to damage cultural heritage buildings in this location or the surrounding location, and old buildings have cracked potential and even collapsed because of added construction load.

The forces/loads at the time of construction that were of concern to the five stages of work, namely the vibration of the drill pile tool, the diaphragm wall, the force due to the decrease in groundwater in the basement area, the force due to active earth pressure, especially during excavation due to the installation of the basement structure, are very close only 5 m from the heritage building.

In addition, materials falling on cultural heritage buildings should be avoided. The potential problems of a three-floor basement building constructed close to cultural heritage buildings. The construction of 3 basement floors close to 3 heritage buildings did not crack architecture.

Three basement floors were dug extra carefully on a narrow land with three sides of the heritage building and the back of the old building. Heritage buildings were protected by law that had not to be changed either intentionally or unintentionally.

3.1. Overview

The decreasing number of water catchment areas also caused a decrease in groundwater levels. Based on the geological and hydrological data analyzed, groundwater conditions in Jatinangor station (approximately 170 km distance from the basement location was my manuscript)in 2015 showed a decrease compared to 2010. Currently, clean water resistance can be ascertained by hydrogeological techniques, namely by building artificial infiltration of groundwater being used (Hidayatullah M.S, Yoga K.E, Muslim D, 2017).

Gap research: There was no research with many problems, namely the construction of 3 basement floors and upper structure was a tall building carried out very close to 3 heritage buildings and one old building. Four buildings with shallow foundations, high groundwater -1.0 m to -2.2m, surrounding restricted site, and very narrow land.

3.2. Decomposition of Forces

The basement floor was in an area of high water level affected by uplifted groundwater pressure, water seepage, and humidity problems through the wall. After it was operating, as time passed, it could be damaged.

3.3. Internally Integrated

The construction should also follow the approved method statement and have a checklist on supervision to prevent mistakes or carelessness in the execution of works, especially those highlighted in this paper.

3.4. Internal Regulation

Regulation Of The Minister Of Public Works And People's Housing Of The Republic Of Indonesia Number 19 the Year 2021 Concerning Technical Guidelines For The Implementation Of Cultural Heritage Building Be Conserved.

Article 6. (1) b. As much as possible, maintain authenticity.

Article 6. (4) c. Careful and responsible use was based on the use of non-destructive techniques, methods, and materials.

4. Result

The result did not crack, there was no deformation, and the heritage building was protected from dust and vibration. Based on potential problems, the researcher prevented in the following way:

- Groundwater was issued in the basement when dug, so groundwater in the basement and surrounding areas was recharged.
- Monitoring was done daily so groundwater degradation did not occur more than 30 cm or did not reduce drastically because the hole outside the basement recharged every day, preventing higher decreases outside the diaphragm wall.
- Dewatering and recharge prepared and calculated properly.
- Groundwater recharged if the decline, groundwater decreased by more than 10 cm should be recharged immediately.
- Heritage buildings were protected by safety nets and tarpaulin.

Quality assurance was carried out to ensure that design and construction were applied systematically with the required checklists. The success of basement 3-floor construction that did not result in damage zero accidents at heritage buildings.

5. Discussion

This manuscript was very necessary as a reference and easy to follow because it is simple and practical for construction work, especially for underground buildings that could damage the surrounding environment, namely buildings and infrastructure. In the isolation environment against vibrations and groundwater levels, there was no deformity, no shear, and even no small cracks. This was very beneficial for the building and infrastructure environment. In the future, it was always identified and applied to all construction work during the construction process.

The vibration was isolated, and the groundwater level was stable; it was very beneficial to keep it from cracking, did not tilt, and was even more profitable when the construction was complete. The groundwater level was kept constant during building operations and maintenance.

The researcher anticipated the Heritage buildings and the stages of construction.

5.1. In Carrying out the Work, Excavation things had to be Considered

The soil and groundwater level condition near heritage buildings and old buildings was monitored at 5 borehole points. Groundwater level ranges from -1.00 to -2.2 from the existing elevation land.

Shallow groundwater needs special attention because dewatering carried out - 15m, which was under the basement three floors; if the groundwater outside the building area drops very large, it causes damage to buildings and infrastructure.

This had to be controlled and monitored properly so that the groundwater outside the basement remained constant. The entrance to the basement should be 50 cm higher than the maximum flood elevation and considered an average subsidence of 7.5 cm/year in Jakarta (in some locations 14 cm/year) due to the deep groundwater used excessively.

During excavation, it had to be calculated against active soil pressure, groundwater pressure, and carload as it passed for loading and unloading while working in the basement.

Oxygen 20 workers at basement floors had to be supplied from above by giving fans and communication tools as well supplied, as other safety equipment, helmets, and eyeglasses.

5.2. Step Construction of the Basement: was Careful and thorough with the Correct Stages

That could result in a damaged building due to vibration Bore pile equipment. D.W. equipment and excavation if carried out without regard to the stages of work. Diaphragm Wall hole to a depth of -27.00 m. The hard ground (end bearing) was between 36 m to 40 m. The concrete diaphragm wall was all compacted so as solid to withstand active ground pressure and forces received. The walls excavated were given bentonite so they did not collapse.

King post profile steel 49 points as deep as 3.5 m was installed to support the floor plate. King post-WF 300x300 profile installed at the top of the bore pile. King post carrying capacity was calculated according to the area supported x (DL + L.L.). It had to be stronger than the load received. Carried out top-down with open cut variations used steel profile retained the basement walls.

The site layout must be attended to during the construction stages (Figure 2).

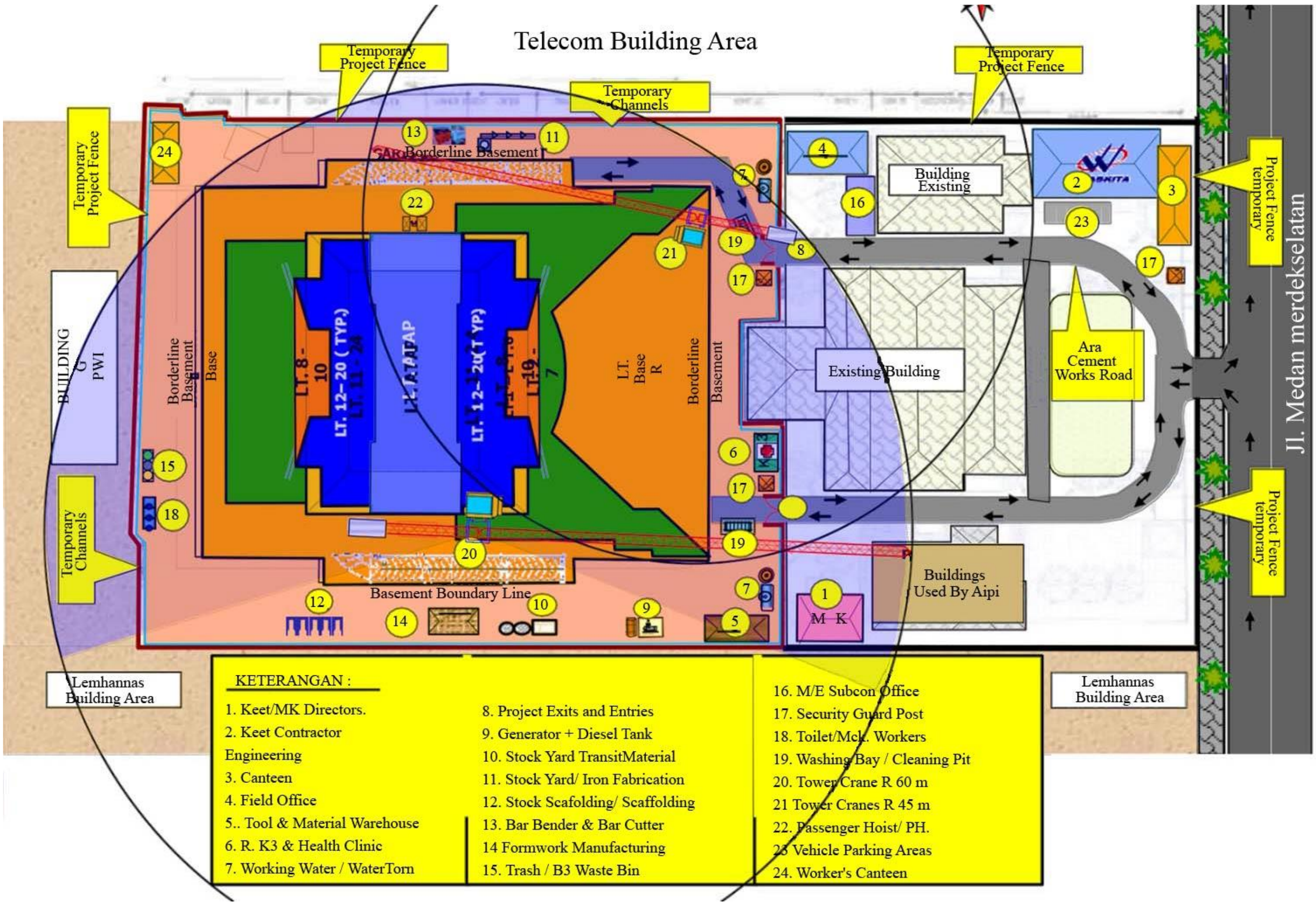


Fig. 2 The site layout was narrow, which should put all the construction needs

The construction method became the main in installing strutting steel because of limited space work (Figure 3).

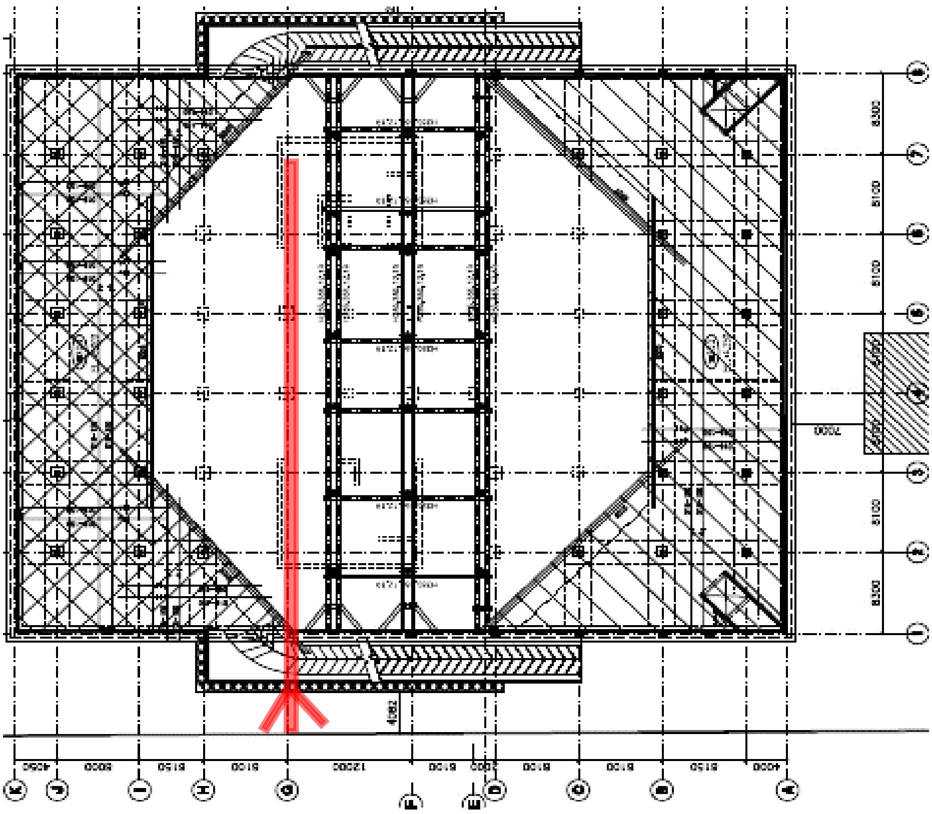


Fig. 3 Zone 1 left, zone 2 middle, zone 3 right. strutting steel position at ground level

Strutting had to be the horizontal force of active soil pressure, groundwater pressure, and pressure building load on the site next to it. The strutting steel should also be calculated for horizontal and vertical deflection (Δ) that

$$M = 6EI\,\Delta / L2. \quad (1)$$

If the deflection was large, resulting in a large moment, it was necessary to add additional strutting strengthening with a larger profile or a double profile. The connection was significant between the steel profile and D.W.; the connection had to withstand the moment due to deflection, especially from the horizontal force, active earth pressure, and material loads for basement construction. The horizontal force in figure 4 had to be supported by steel profile strutting.

$$Ka = \tan^2(45 - Ø) \quad (2)$$

$$P = 1/2 x Ka x \omega x (h_c)^2 \quad (3)$$

$$Pw = \gamma\, h^2/2 \quad (4)$$

$$Pl = q \times h \quad (5)$$

$$P\ total = P + Pw + Pl \quad (6)$$

Ka	=	coefficient of active earth pressure
Ø	=	angle of internal friction angle of shearing resistance of a soil
γ	=	weight of soil volume density soil volume
H	=	height in general=hydraulic head
hc	=	vertical distance from the ground surface of cohesive soil to a point of zero stress
γ_w	=	unit weight of water
q	=	load

P total was pressure against D.W. due to added groundwater pressure (Figure 4), active soil pressure, loads around the basement, environment car access road, and box car carrying books and office purposes.

5.3. Groundwater during Dewatering

Recharge to outside basement construction. Dewatering done in the diaphragm wall area (Figure 5) Groundwater outside the diaphragm wall should be monitored and measured, and groundwater should not be drastically dropped to avoid the impact of damage to heritage and infrastructure buildings. The outside basement recharged always keeps the groundwater level.

The location recharge was distributed to the location where the point of the heritage building was closest and spread out in various directions so high reduced groundwater could be avoided.

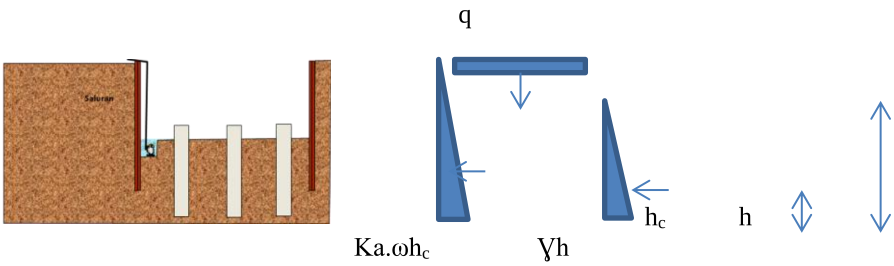


Fig. 4 The force that works on D-wall

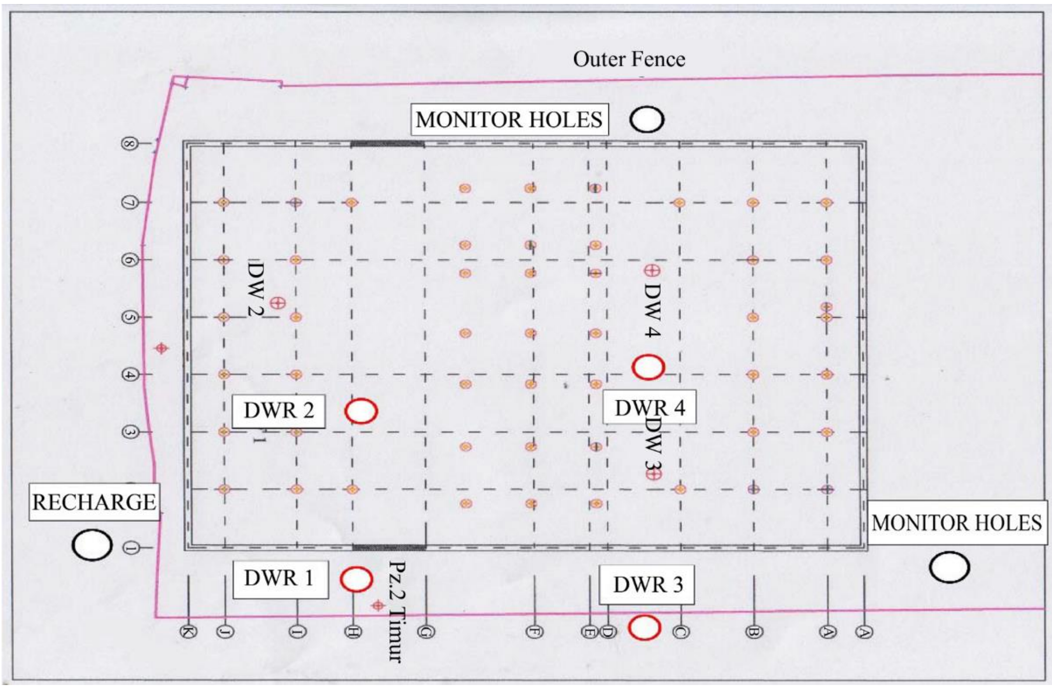


Fig. 5 Dewatering (D.W.) and Recharge (Pz) location

5.4. Groundwater Level Monitoring

Monitoring and observation mainly decreased groundwater on the basement floor and restored groundwater level outside the basement where the researcher anticipated risk for up and down groundwater, especially very shallow groundwater, such as research sites.

Groundwater flow theory Bernoulli law $h = z + U / \gamma_w$ (7)

h	=	total pressure height at one point.
z	=	height of elevation power.
U	=	pore water pressure.
γ_w	=	unit weight of water.

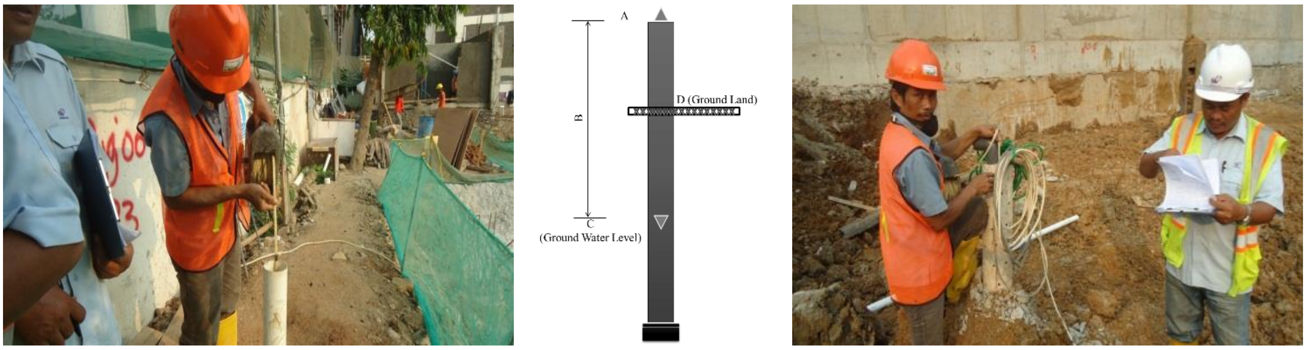
To predict the groundwater level in this area during dewatered and recharged. The existing groundwater level was -1.00 m before being dug into the ground, decreasing gradually from -5.25, -10.00 to -15.00.

The existing groundwater level was -1.00 m before it was dug and decreased gradually from -5.25, -10.00 to -15.00.

Piezometer and Inclinometer were installed as monitored equipment to monitor the groundwater level reduction in the vicinity of the building.

Dewatering and recharging inside and outside the basement area when it drops more than 30. cm outside the basement area. The groundwater level was monitored water level every 24 hours.

After recharging, observations of groundwater levels (Figure 6 a,b,c), and the engineer's inspection of the walls of heritage buildings, no deformation/ unchanged remains.



(a) (b) (c)

Fig. 6 (a) Recharge, (b) Measurement noted and (c) Groundwater control (source: author document)

5.5. Groundwater Recharging

Management of water had to be recycled, and soil disposal had to be immediately outsited, with limited workspace.

- Excavation was relatively wet because high groundwater was about -1.00 to -2.2 m from the soil surface. The project area was slippery, and the ground area gave a precast concrete plate so workers did not slip.
- Water mixing with soil was immediately discharged into the drainage, but the drainage was given a soil filter so the water entering the drainage was not dirty. The excavated land was accommodated in a large tent, then tied and out site brought dump truck. Before the truck went out, it was tire-washed.

Water monitoring should analyze the decline; groundwater decreased by more than 30 cm should be recharged immediately. Example (fig 6 a,b,c) Measurement of top-level A, measuring the high to B every day, the difference of high B every day indicated the decreased groundwater. Level A measurement with length B resulted in level C. The difference between level C and level D indicated the groundwater level on the soil surface.

Example: the dewatering pit 1 monitored: On 5 July 2015, hour 15 showed B (longer) 6100 mm, whereas on 6 July 2015, clock 15 showed B (length) 5690 mm, decreasing groundwater by 410 mm. This was to beware of large water degradation within 24 hours, so it was recharged twice a day, morning and afternoon.

The purpose of this explanation was that simple measurements could be made for jobs with a high level of risk; this was very easy to do by workers with relatively low education. This was how I, as a researcher, always provided solutions that were easy to work with but provided great benefits.

6. Conclusion

Novelty: lowered groundwater from -1.0 m to -15m. The 3-story basement succeeded without crack and no deformation with easy construction by the site engineer, although near the 1 old building, 3 heritage buildings used shallow foundations, expansively soil, and had high groundwater.

The basement construction succeeded but did not crack the heritage building. This novelty was the right solution because many old or heritage buildings in the world cracked or failed if construction was near that building. In previous research, there was no basement on more than 1 floor very near heritage buildings. The steady groundwater level maintained around buildings and infrastructure during the operational and maintenance building period, such as my manuscripts, needed to be implemented for every project so that buildings and infrastructure did not crack, deform or slide.

The author had anticipated five potential problems, especially quality management and safety management.

Groundwater was monitored with a piezometer, and deformation with an inclinometer. The dewatering and recharging were observed with simple and easy construction, as shown in figures 6 a, b, and c, measuring with hose and meter until groundwater fixed the first level. This research applied 5 main groups, starting from bore piling, excavation, installing basement walls and floors, monitoring groundwater, and protecting the environment so that heritage buildings and old buildings did not crack and deform, the environment was not polluted, clean and healthy.

The result of the 3 floors construction basement with 27 floors building had no architectural cracked heritage buildings so the authenticity of the heritage buildings was maintained, which was highly expected in every heritage building. A great solution in a simple way was expected in every construction. This manuscript could be a simple solution and easily understood by engineers. The author's philosophy was that scientific manuscripts should be easy for applied engineering practitioners and young scientists.

Major findings and policy recommendations that needed to be implemented for each project so that the existing building and infrastructure were not cracked are described below.

- In big-city neighborhoods, buildings and infrastructure were close together. Every time excavation activities, groundwater around buildings should be kept at the same level. When changed drastically, it will result in buildings or infrastructure changing, resulting in cracks.
- Groundwater monitored during drought or rain during operational building to anticipate changes in groundwater levels that resulted in deformation in buildings or infrastructure.
- Basement Construction of limited space when using strutting steel should be planned for basement structure activity. Stages construction indicated success without crack building.
- Vibration should be reduced and not cracked during construction building. At the time of the bore pile and diaphragm wall construction, there was no wide trench to cut the wave before the diaphragm wall was installed.
- The environment had to be kept clean, not slippery. All waste from excavation and groundwater had to be out of the site immediately. The soil-mixed groundwater had to be filtered to achieve the quality standard requirements.

Indonesia is a developing country with limited resources. The researcher tries to apply simple engineering and construction and simple engineering mechanic calculations, but it is very necessary for zero accidents, zero cracks, and no deformation. The researcher tries to provide a simple, indispensable solution in the construction world. Researchers provide solutions so that there is no failure and heritage buildings do not experience deflection and settlement so that heritage buildings like the original are not changing. All contractor teams, such as engineering, assist the author in realizing what is to be done in research. The author states that he has no conflict of interest; the author was solely for knowledge and provides solutions to preserve heritage buildings according to the original.

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