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IDENTIFICATION OF CAUSES, AND PREVENTION OF DEFECT STRUCTURE AND REPAIR METHODS IN THE IMPLEMENTATION OF HIGH-RISE BUILDING CONCRETE CONSTRUCTION (Case Study of The Newton 2 Apartment Project)

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ABSTRACT

Concrete is one of the materials that is often used in various construction projects. This is due to several advantages possessed by concrete, including when viewed in terms of cost efficiency, concrete has cheaper work and maintenance costs compared to steel, besides that when compared in terms of flexibility, concrete will be more easily formed as desired depending on the shape and strength of the formwork. In the implementation of construction projects, several problems are often encountered, including damage to the concrete structure, which weakens the building structure. The use of concrete in building construction also requires continuous evaluation and repair or reinforcement of the structure so that the concrete can function again at a good performance.

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1. INTRODUCTION

The construction of construction projects, both structural buildings, and civil construction buildings such as roads, bridges, dams or dams, water buildings, airport runways, and others often use concrete as a construction material. This is because some of the advantages possessed by concrete include cheap work and maintenance costs , durability (durability or resistance) to the influence of weather, chemical influences, and erosion, high compressive strength, wear-resistant, fire-resistant, and easier to form as desired depending on the planned shape and size. But like other building materials, concrete also has weaknesses that can cause damage or defects in concrete, such as prone to cracking due to the nature or characteristics of concrete that has low tensile strength, difficult to be perfectly waterproof, concrete easily shrinks and expands when there is a change in temperature, therefore to prevent cracks it is necessary to make dilation *(expansion joint).*

The materials and constituents used greatly affect the quality and performance of the concrete itself, such as water, cement, coarse aggregate, fine aggregate, and other additives. The use of concrete in building construction also requires quality evaluation and implementation in the process, so that the structure can function in accordance with the planned age. The aim is to systematically determine the strength of the analyzed structure, including material properties, geometric dimensions and structural conditions in the field. (Poerwodihardjo dan Istiningsih, 2020)

In the implementation of construction projects, it is vulnerable to various problems, one of which is damage and defects in building structures. Damage to the structure can be found at several points such as plates, beams, columns, and concrete walls. This can result in a decrease in the performance and strength of the structural elements of a building, cause a chain effect and damage to other building parts and have an impact on disrupting the function of the building thereby reducing the quality and quality of concrete. Some concrete damage that often occurs in the field, such as: porous concrete, concrete cracks, *honeycombs* or voids, and turning ngeplint, if the structure is damaged it requires repair or reinforcement. Here are some types of damage that occur to concrete:

a. Retak *(Cracks)*

According to (Isneini, 2009) Concrete *cracks* are the occurrence of rupture in concrete in the form of relatively long and narrow lines. Cracks can be broadly classified as structural and non-structural cracks. Structural cracks are the most vulnerable indication of the condition of a building. Occurs due to the

influence of load carrying capacity that exceeds capacity and errors in design, so that it can endanger the building. One example of structural cracks is cracks that spread to parts of concrete structures. While non-structural cracks generally do not directly have an impact on reducing the strength of building structures.

b. *Honeycomb* atau *Voids*

Honeycomb or voids can be defined as a surface that is rough and hollow or hollow in concrete so that it forms a *honeycomb-like* pattern. Although *honeycombs* or voids are small, the damage cannot be ignored because cracks can spread or enlarge. In some cases, reinforcement in concrete can be seen due to the hole. So that it can cause an increase in the corrosion rate of reinforcement which will have an impact on the strength of the building structure.

c. Deformation Concrete

Deformation is the control of the stability of structural elements related to their strength. In general, deformation is expressed as a change in the shape of a part of a structure such as an arch and a displacement of position from a span point to another point. (Pala'biran et al., 2019).

According to (Tuwanakotta, 2020), Deformation or deformation may occur in the structure. UBC, ACI, and SNI have set limits on structural deformation in both beams and columns *(story drift).* Deflection occurs in laying, foundations, *columns, slabs*, and walls that can be visually seen as bending, curvature or changes in the shape of the structure.

2. METHODS

This research was conducted at *The Newton* 2 Apartment Project on the 14th (fourteenth) floor to the 37th (thirty-seventh) floor, located on Jl. Karet Sawah, Kuningan, Karet Semanggi, Setiabudi District, South Jakarta City, Special Capital Region of Jakarta.

Figure 1. *The Newton* 2 Apartement Project Front View
Sumber : PT. Tatamulia Nusantara Indah

The type of data used consists of 2 types, namely primary data and secondary data. Primary data was obtained by direct survey in the field at The Newton 2 Apartment Project. Secondary data is obtained based on supporting data sourced from the internet, or other literature studies related to research material, as well as books or journals or other reference sources.

The research process is carried out through several stages. Collection of data sources and information through literature studies related to several causative factors *and repair* methods on concrete damage that can be used as a reference and reference in making observations in the field. The next stage is the review and collection of data directly in the field. This is done by conducting a direct survey of the construction implementation process, so as to obtain accurate data related to several causes of concrete damage and prevention. After observation and data collection are complete, the data will be processed and analyzed for conclusions.

3. RESULTS AND DISCUSSION

Causes of damage caused to concrete

a. Retak *(Cracks)*

Concrete damage can be caused by various factors such as: errors in calculation or preliminary planning, weather and climate conditions, process or execution errors and poorly paid maintenance work.

Cracks can be caused by various things, including (1) Acceleration of the water evaporation process in the concrete mixture due to air factors, concrete temperature, humidity and wind speed on the concrete surface when the concrete is still in a plastic state until the final setting time, which causes the concrete to shrink. While concrete that does not bleed will shrink after that there is a tensile stress on the weak concrete, causing cracks. The damage to these cracks is superficial and interrelated, patterned parallel to equal or irregular distances. This type of crack is called a *plastic shrinkage crack*. (2) Shrinkage at the time of drying due to after the concrete hardens perfectly, when the process reaches the strength of the characteristics of the concrete structural elements shrink causing cracks and this can occur if the treatment *(curing)* is not done properly and there is no *contaction* or *expansion joint* well. The shape of the crack can be recognized by the characteristics at the end of the crack that appear from one side of the surface, creeping and irregular, and mostly parallel to the overlapping crack . This type of crack is called *a drying shrinkage crack.* (3) The temperature difference in the concrete mixture during concrete printing time to concrete hardening *(concrete setting time).* The temperature will continue to rise as a result of the reaction of water and cement. So when the temperature of the concrete is too high, cracks often arise on the concrete surface when the concrete hardens. This type of cracking is called *thermal cracking.* (4) The influence of structural movement, poor joint position between beam meeting with column or plate and unstable ground conditions. Cracks are deep and wide, this type of crack often debuts with *random cracks.* Cracks need to be repaired if they reduce the strength, rigidity, and durability of the structure. (ACI 224R-01, 2001)

According to (Yurmansyah dan Mukhlis, 2012) Cracks in concrete are divided into 2 types, namely inactive cracks and active cracks. Inactive cracks, this type is not developed / stable or better known as *dead-cracks.* And the second is active cracks, these cracks continue to increase both in length and width of the crack, or better known as *live cracks.*

Figure 2. Cracked Concrete on the 27th Floor of *The Newton* 2 Apartment Project (analysis results)

Cracks can be recognized by three parameters: length, width, and pattern. Generally, the width of this crack is difficult to measure because of its *irregular shape.* In the concrete hardening stage there are micro cracks, these cracks are difficult to identify because the size of the money is too small. In checking the width of micro cracks usually used a tool called a *Crack Microscope* whose width varies between 0.125 - 1.0 µm (in the first 8 hours after printing). The minimum crack width is 0.13 mm (0.005 in), otherwise known as microcracking. Microcracks when loaded can become major cracks or larger cracks. The maximum allowable crack width can be seen in **Table 1.** next:

Table 1. Maximum Permissible Crack Width [ACI Committee 244, 1972]

Types of Structures and Conditions	Crack Width Tolerance(mm)
Indoor structure, dry air, application of waterproofing coating	0,41
Outer structure, moderate humidity, no corrosive influence	0,3
Outer structure, moderate humidity, no corrosive influence	0,18
Structures with high humidity and	0,15
Structure with regard to water	0,1

b. *Honeycomb* atau *Voids*

Honeycomb or more commonly known as *Voids* arise when concrete fails to fill the areas in the formwork, caused by various factors, including: (1) *Workability* in concrete is not suitable, for example the use of concrete mixture that is too rigid and viscous resulting in the difficulty of the concrete mixture reaching every part of the reinforcement and structural elements, (2) Compaction carried out using a

vibrator is not good, (3) The distance between the formwork and the reinforcement or the distance between the reinforcement is too tight, as a result, the mortar part cannot fill the cavity between the coarse aggregate properly and may increase the rate of corrosion of the reinforcement, which affects the strength of the building structure. (Saputra et al., 2014)

Figure 3. Concrete *Honeycomb* or *Voids* on the 19th Floor of *The Newton* 2 Apartment Project (analysis results)

c. Deformation Concrete

Deformation or deformation of structural elements can be caused by several factors, including: (1) Overload, (*2) The influence of reinforcement corrosion, (3) Errors in planning and calculation as well as design, earthquake loads and shrinkage.* Deflection, with the formation of internal stress inside the concrete can cause *spalling* on the concrete surface. So that the reinforcement can be exposed and cause corrosion.

Figure 4. Concrete Deformation On The 20th Floor Of *The Newton* 2 Apartment Project (analysis results)

Methods for the prevention of concrete damage

Prevention of construction damage needs to be considered to minimize errors in the project, the implementation of a strict management system and regulations in the project with discipline to comply with applicable Standard Operating Procedures (SOPs), so it can be ascertained that it can prevent and reduce the risk of structural damage. Each construction project has different challenges and problems but in general the same. One of the mistakes that often occurs in project construction is at the stage of implementing structural work. Many of the workers and implementers of construction assume that structural work will later be continued by architectural work so that many structural works are not perfect. While the structure is the key to the level of security when the building is operational.

In the process of casting structural elements, it is necessary to pay attention to several stages in implementation, including the following: (1) Preparing scaffolding, formwork, and *shop drawing* as guidelines in the implementation of work. (2) If it is in accordance with *the shop drawing* or working drawing, the installation of reinforcement and formwork will continue. If the checking is appropriate, then proceed to the casting stage. (3) *Curing* or concrete treatment. (4) After that, the dismantling of the formwork and observation of whether there is damage to the concrete is then analyzed the cause of damage and continued the repair stage of damage.

For further explanation regarding the implementation method can be seen in **Figure 5.** next:

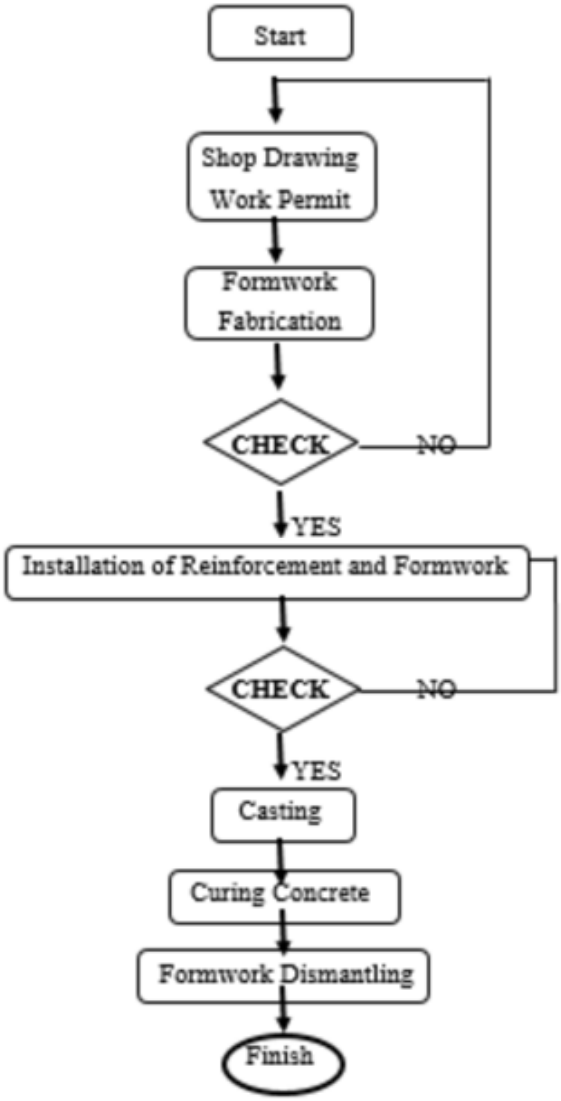

Figure 5. *Concrete* Implementation Flowchart
(Ariyanto, 2020)

Methods of Implementation of Concrete Damage Repair

Repair of the structure according to (Triwiyono, 2004) carried out for buildings that are vulnerable to new loads that must be supported. So it is necessary to increase the strength of the building or add new structural elements that are not available or considered non-existent during the process of working on the structure. Structural reinforcement is usually done as a preventive measure before the structure is destroyed. If there is damage to the building, repairs must be made immediately. Structural repairs are applied to buildings that require efforts to restore the function of the structure as before after a decrease in reinforcement. If the building is not immediately addressed both repair and reinforcement, it will have an impact on other structural elements. Rehabilitation measures are needed which can be in the form of strengthening *and* retrofit. Here are some methods *of repairing* damage to concrete:

a. Structural Cracks

In this condition, concrete experiences deep cracks with a crack depth of > 3 cm and a crack width of > 0.3 mm. For the implementation of the repair can be seen in **Figure 6.** next:

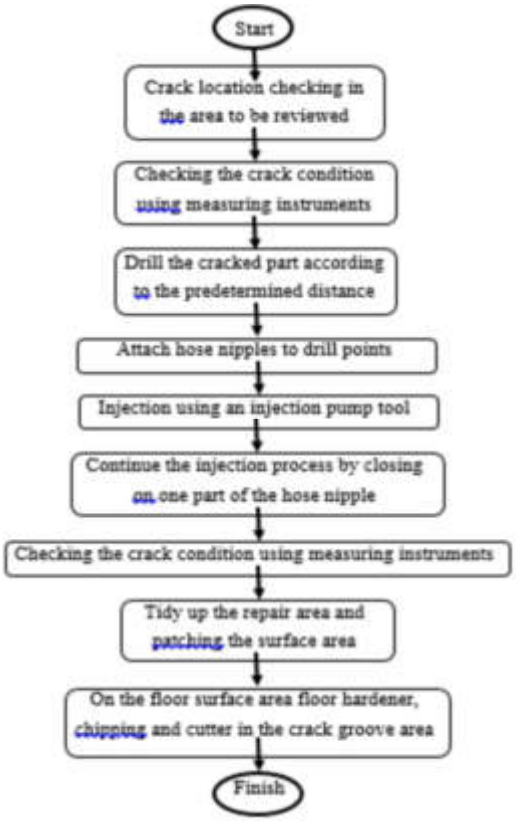

Figure 6. *Flowchart* of Structural Crack Repair Implementation
Source : PT. Tatamulia Nusantara Indah

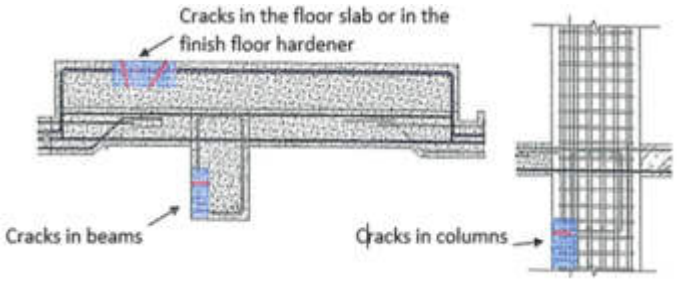

Figure 7. Parts of the structure that have suffered concrete damage
Source : PT. Tatamulia Nusantara Indah

Figure 8. Methods of Repairing Damage to Concrete Structural Cracks (analysis results)

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Based on the picture above, the process can be sorted, including:

1. Check the crack location in the area to be reviewed,
2. Check the condition of the damaged building using a crack measuring instrument called a *Crack Microscope,* then make a floor plan *(mapping)* images related to the position and location of cracks,
3. If the dimensional measurement results meet the criteria for deep cracking, then repairs are carried out on the cracked concrete part, the distance between drill points is 20 cm along the crack area,
4. Install the inlet *and* outlet hoses (nipples) *at the drill points,*
5. Then the injection uses an injection pump with a pressure of 1-3 bar so that the injection material can be filled properly. The material used is *sikadur* 752. Perform the injection process gradually, from the end of the side of the crack area on the first hose, after the cavity is fully filled the mixture will come out on the second hose

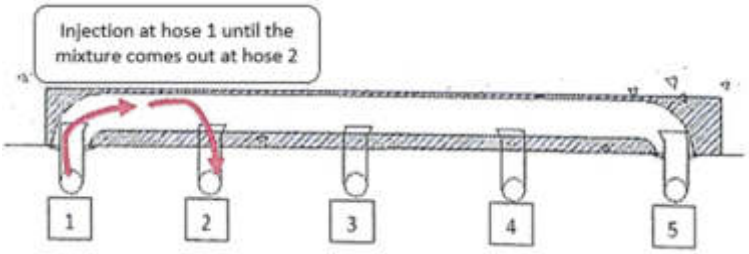

Figure 9. Repair Process with Concrete Injection Method
Source : PT. Tatamulia Nusantara Indah

6. Continue the injection process by closing the first hose by closing the first hose by tying the hose, after that do the same steps until the cavity is fully filled with the *752* sikadur mixture.

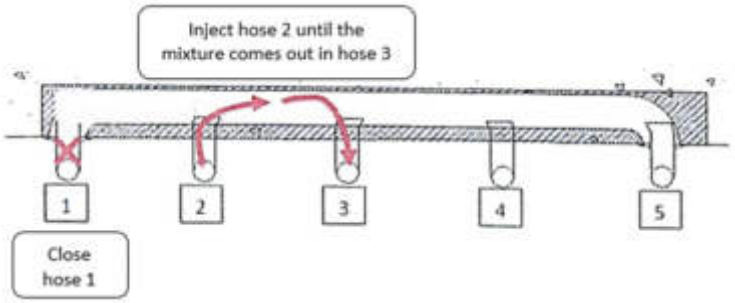

Figure 10. Repair Process with Concrete Injection Method
Source : PT. Tatamulia Nusantara Indah

7. After completion of the injection, tidy up the structural repair area and *patch* the concrete surface area using ex sika patching, *for structural cracking,* patching *must not use scrambled materials* .

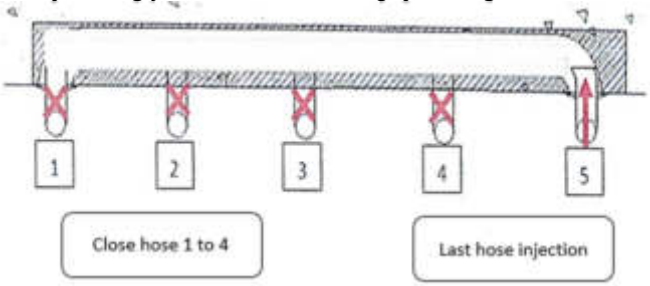

Figure 10. Repair Process with Concrete Injection Method
Source : PT. Tatamulia Nusantara Indah

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8. After For floor *hardener floor area, chipping* and *cutter* in cracked groove area of ± 5-10 cm. Carry out the *concrete surface patching* and injection process using concrete screws. In semi-dry conditions, sow *floorhardener ex ultrachem* material and rub using raskam the area until smooth.

b. Non - Structural Cracks

In this condition, concrete experiences deep cracks with a crack depth of ≤ 3 cm and a crack width of ≤ 0.3 mm. For the implementation of the repair can be seen in **Figure 11.** next:

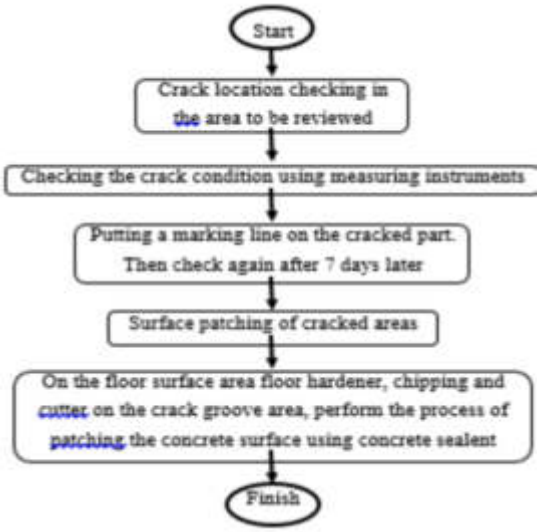

Figure 11. Flowchart of Non-Structural Crack Repair Implementation
Source : PT. Tatamulia Nusantara Indah

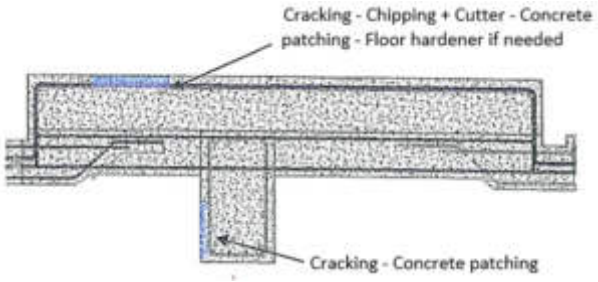

Figure 12. Repair Methods of Non-Structural Crack Damage to Concrete
Source : PT. Tatamulia Nusantara Indah

Based on the picture above, the process can be sorted, including:

1. Check the crack location in the area to be reviewed,
2. Check the condition of the damaged building using a crack measuring instrument called a *Crack Microscope,* then make a floor plan *(mapping)* images related to the position and location of cracks,
3. Give marking lines to the cracked parts. Then check again after 7 days later, if the crack width and crack length increase, it can be categorized as structural cracks,
4. If the dimensional measurement results meet the criteria for light cracking, *concrete surface patching* uses A4 ex *demix concrete skim for basement floor area to mezzanine floor and* SM831 ex star mortar *concrete skim* for mezzanine floor area *to roof,*
5. For floor *hardener floor area, chipping* and *cutter* in cracked groove area of ± 5-10 cm. Carry out the *concrete surface patching* process using concrete screws. In semi-dry conditions, sow *floorhardener ex ultrachem* material and rub using raskam the area until smooth.

c. *Honeycomb* atau *voids*

In this condition, concrete experiences structural porous with a depth according to the criteria table. For the implementation of the repair can be seen in **Figure 13.** next:

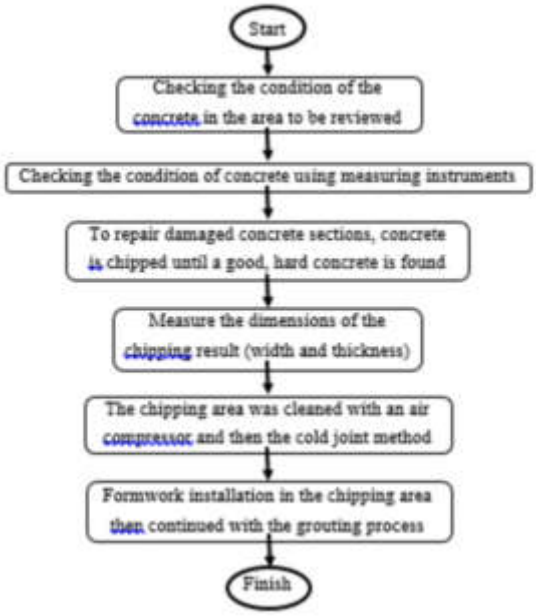

Figure 13. Flowchart of Implementation of Honeycomb or Voids Concrete Repair
Source : PT. Tatamulia Nusantara Indah

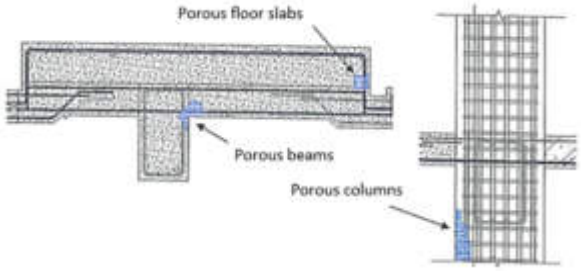

Figure 14. Parts of the structure that have suffered concrete damage
Source : PT. Tatamulia Nusantara Indah

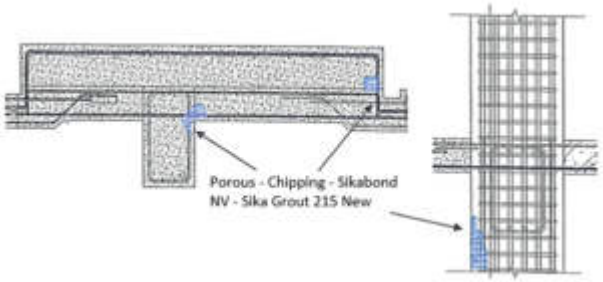

Figure 15. Honeycomb Concrete Damage Repair Method or *Voids*
Source : PT. Tatamulia Nusantara Indah

Based on the picture above, the process can be sorted, including:

1. Check the condition of the concrete in the area to be reviewed,
2. Check the condition of the damaged building using a measuring instrument, then make a floor plan *(mapping)* drawings related to the position and location that needs to be repaired,

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3. For repairs to damaged concrete parts, concrete is chipped, *until hard and good concrete is found, (4) Measure the dimensions* of chipping results *in the form of area and thickness,*
4. If the results of the dimension measurement meet the criteria, clean the former parts that have been *chipped, then repair using the* cold joint *method, namely* by flushing the surface with clean water until saturated with water, then apply *bonding agent Sika Bond NV,*
5. Next, the installation of formwork in the *chipping* area then the grouting area *using* Sika Grout *215* New *with a pressure* grouting casting of 1-3 bar. For a thickness ≥ of 100 mm, it must be combined with aggregate usage according to Sika Grout 215 New specifications *(Maximum 40% of the total weight of* Sika Grout 215 *New).* For the structural parts of columns*, shear walls,* and beams that result if the loss is known to exceed the position of the main reinforcement, then during the repair work process, these structural elements must be supported using scaffolding.

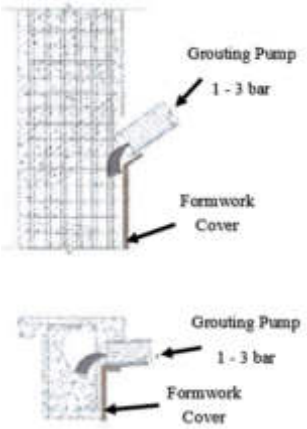

Figure 16. Honeycomb or Voids Concrete Damage Repair
Source : PT. Tatamulia Nusantara Indah

d. Deformation Concrete

In this condition the concrete undergoes a change in shape, the concrete is not straight, shifted or tilted. For the implementation of repairs can be seen in **Figure 17.** next:

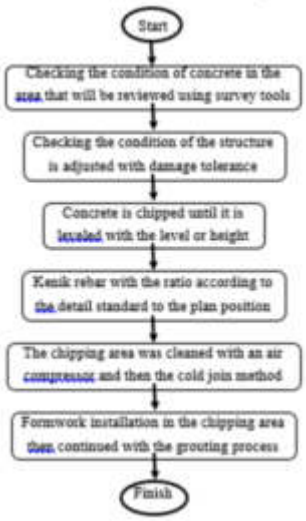

Figure 17. *Flowchart* of Concrete Deformation Repair Implementation
Source : PT. Tatamulia Nusantara Indah

Figure 18. Methods of Repairing Deformation Concrete Damage
Source : PT. Tatamulia Nusantara Indah

Based on the picture above, the process can be sorted, including:

1. Check the condition of the concrete in the area to be reviewed,
2. Check the condition of the damaged building using a survey tool, then make a floor plan *(mapping)* drawings related to the position and location that needs to be repaired,
3. Checking the condition of the structure is adjusted to the damage tolerance, as follows:
    a. 5 mm slab *flatness* ≤ in 1 m
    b. 25 *mm* ≤slab shift
    c. Deformation and slope and shift of 25 mm beams or columns ≤
4. Concrete is *chipped*, until it is equated to its level or height,
5. If iron is visible, it must be *marked* in a ratio of 1:6 according to *detailed standards* to match the planning position
6. Former parts that have been *chipped*, then cleaned using an air compressor and then make repairs using the *cold joint method* , namely by flushing the surface with clean water until saturated with water, then applying the *bonding agent Sika Bond NV*
7. (7) Furthermore, the *chipping* area is installed formwork and the area is re-casted using Sika Grout 215 New with a *thickness record* of 100 mm, must be combined with the use of aggregate according to *Sika Grout 215 New specifications (Maximum 405 of the total weight* of Sika ≥Grout *215 New)* or concrete of the same quality .

4. CONCLUSION

Causes that have the potential to cause damage occur in the construction structure work phase due to the influence of load carrying capacity that exceeds capacity and errors in design and planning. Causes that have the potential to cause concrete damage in post-construction work include problems during concrete *curing* , problems in installing and removing formwork. Rehabilitation measures are needed which can be in the form of *strengthening and* retrofitting *in* the implementation of construction projects so that the structure can function in good performance.

REFERENCE

[1] ACI 224R-01, 2001. Control of Cracking in Concrete Structures Reported by ACI Committee 224. ACI 224R-01. ACI Comm. 224R-01 1–46.
[2] Ariyanto, A.S., 2020. Metode Perbaikan Pencegahan Beton Bunting Pada Pelaksanaan Konstruksi Beton (Studi kasus Apartemen dan Hotel Candi Land Semarang). Bangun Rekaprima Maj. Ilm. ... 06, 21–29.
[3] Isneini, M., 2009. Kerusakan dan perkuatan Struktur beton bertulang. Rekayasa J. Ilm. Fak. Tek. Univ. Lampung 13, 259–270.
[4] Pala'biran, O.A.S., Windah, R.S., Pandaleke, R., 2019. Perhitungan Lendutan Balok Taper Kantlever Dengan Menggunakan SAP2000. J. Sipil Statik 7, 1039–1048.
[5] Poerwodihardjo, F.E., Istiningsih, D., 2020. Evaluasi Kerusakan Beton dan Metode Perbaikan. Teodolita 21, 65–68.
[6] Saputra, A.G., Taran, R., Sudjarwo, P., Buntoro, J., 2014. Identifikasi Penyebab Kerusakan pada Beton dan Pencegahannya. J. Tek. Sipil Univ. Kristen Petra 3, 1–7.
[7] Triwiyono, A., 2004. Perbaikan dan Perkuatan Struktur Beton. Top. Bahan Ajar, UGM, Yogyakarta.
[8] Tuwanakotta, E., 2020. Identifikasi Tingkat Kerusakan Pelat Lantai Tiga Kampus Politeknik Saint Paul Sorong. J. Karkasa 6, 22–26.
[9] Yurmansyah, I., Mukhlis, M., 2012. Perkuatan Struktur Beton Gedung dengan Metode Grouting dan Glass Fiber. Rekayasa Sipil 5, 46–59.