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# Repair and Rehabilitation of water leaks in concrete structures

*Water retaining Sub and Superstructures, Sleeves, Cable pull pits and duct banks*

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**Abstract:**

This article presents an overview of repair and rehabilitation techniques for the resolution of leaks in concrete structures. Arresting and rectification of water leaks into the building is one of the most challenging activity in the field of construction, especially in areas where the water table is very high. The various repair and rehabilitation techniques are discussed in detail, including the use of mechanical sealants, polyurethane epoxy foam and resin injection methods. The process involves identifying the source of the leak, assessing the damage, and implementing a comprehensive repair and rehabilitation plan to ensure the safety and durability of the structure. The various type of methods described in this article provides a choice to choose the appropriate method required to be used to arrest the leak in a particular structure, depending upon the type of the leak and its consequences.

**Introduction:**

Leakage in concrete structures is a serious problem that can cause structural damage and health hazards. Repair and rehabilitation of leaks in concrete structures is a complex process that requires specialized knowledge and expertise. It may involve the use of specialized materials, such as waterproofing membranes, grouts, sealants, and other products. Additionally, it may include the repair of damaged components, replacement of damaged components and installation of new systems etc. In some cases, the entire structure may need to be replaced. Regardless of the complexity of the repair and rehabilitation work, it is essential to ensure that it is properly executed to prevent further damage and to ensure the safety and longevity of the structure.
It has been widely noticed that in many completed and ongoing projects, the substructure of the building is damaged externally and internally by the leakage of water into the building. This article takes us through the concept and complete process involved in the identification, rectification and arresting the water leak inside the building and also the various technologies that are used in this process.

- **Leak Identification and investigation**

One of the most critical phases of arresting the water leakage is detecting and identifying the leak point or the source of leak. Water leak is commonly observed in both types of structures such as

- Easily accessible structures
- Structures that can be accessed with difficult methods.

Generally, for easily accessible structures such as water retaining structures above ground level and RC structures accessible from inside, identifying the leak source can be easily done through the physical witnessing inspection.
On the other hand, for the structures that are accessed with difficulty such as underground services including duct banks, the leak point/source cannot be detected through the physical inspection. In this case, where the source of the leak is from duct bank sleeves encasement buried under the soil, a mini camera with a push bar that is monitored by CCTV is recommended to be used for accurate detection of the leak points through pull pits or trenches. One of the limitations of the push bar CCTV camera is that they cannot be used to identify the leak points of duct bank sleeves that are buried with the live cables.

- **Leak rectifications Proposals & Methods**.

The leak rectification procedure and methods are not the same for all types of leaks and structural damages. Depending upon the size, location and type of the damage and repair, different methods shall be used to effectively arrest the leak. Choosing the wrong method to arrest the leak shall result in failure. The most prominently used methods of leak rectification are briefly described below:

❖ **Foam and resin injection**

In the case of easily accessible water retaining structures, the most common method used and recommended to arrest the leakage is Polyurethane (PU) foam and resin injection method. In general, the PU foam injection method shall be used as a temporary solution to arrest the leak, whereas to have a permanent solution, the PU resin injection method shall be used.

In case of any ordinary leak in water retaining structures, PU crack injection resin shall be used by injecting through the crack to seal moving and non-moving cracks in concrete structures in order to obtain a permanent durable sealing effect. Basically, it is a two-component solvent-free, low viscosity flexible polyurethane resin system which reacts to form a flexible and impermeable barrier in both dry and damp conditions.

In case of a very heavy leak and wide cracks where there is a large flow of water, it is advised that prior to injecting the PU crack injection resin, PU crack injection flexible foam shall be injected initially to stop flowing water temporarily, over which the PU resin shall be injected. PU foam is designed as a pre-injection process and also injected through the same leak points to immediately stop the water flow for a temporary period of time and facilitate further operation. PU Foam is especially known for its strong increase in volume (almost 7 times) when it is in contact with water.

Moreover, the PU injection method can be used in case of high-pressure water, e.g. in dams, basement RC walls, concrete water tanks, tunnels and bridges, pull pits and duct banks.

The surfaces of cracks to be treated shall be free from dust, loose particles, oil/grease etc. Holes shall be drilled along the length or adjacent side of the crack in a staggered manner, to fix the injection aluminium packers. Distance between the drilled holes depends upon the crack and thickness of the section (200-500mm). Holes adjacent to the crack shall be drilled diagonally at an angle of 45 degrees and shall pass the crack at the middle of its depth. The injection packers shall be fixed and made rigid with the application of high-strength epoxy adhesive to bond crack injection packers to concrete in order to withstand the high pressure as described in the Figure.1 below.

Usually, the PU injection is carried out with a single component pressure pump having minimum pressure of 4 bars. The outlet of the pump shall be connected with the inlet of the surface fixed injection packer nozzle as detailed in Figure.2 below. The PU resin shall be injected until the crack is sealed and the resin comes out from the adjacent injection port or oozes out from the surface of the crack as detailed in Figure.3 below.

For vertical cracks, the injection shall be done from the lowermost injection port and moved upward and for the horizontal cracks, injected from the first port at one end and shall move in one direction attending all the ports till the end. The injected resin shall be allowed to cure completely, the external packers shall be removed and the surface shall be cleaned.

In addition, a single product made of a combination of PU injection foam and resin is available for a permanent sealing effect with fast foam formation. It combines the positive properties of PU foam and PU resins. However, it is suitable for specific applications only such as crack injections and damp-proof courses in case of large cavities.

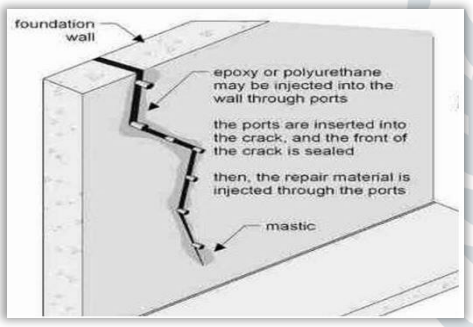


Figure1: Wall with crack and the packers position

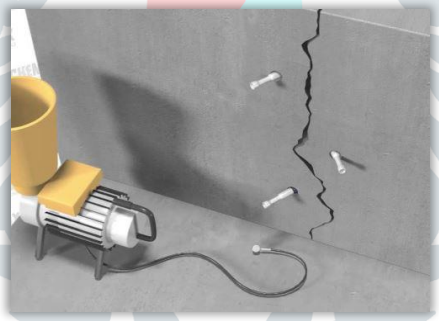

Figure2: Packers are injected with resin through the pump

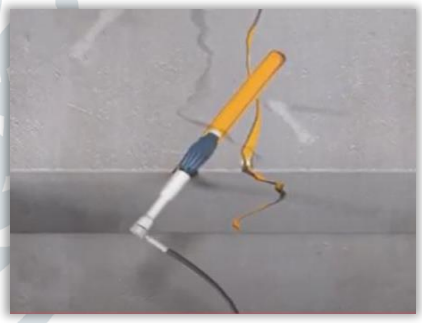

Figure3: Resin is filled in the cracks properly

❖ **Curtain injection (Gel)**

Curtain injection is recommended to arrest the leak for the structures, where excavation is not possible for technical and cost-effective reasons or incase of cracked building components, that are subjected to considerable movement. It is also used for the post-construction sealing of structural elements that are directly in contact with the ground and affected by the moisture. It is suitable for restoring basements, shafts, canals and tunnels.

In general, the main components of the curtain injection system are stainless steel packers, 2 component compressed air operated Pump, and Gel injection components as detailed in the Figure.4 below. Initially, holes shall be drilled through the structure, using a drill machine to fix the injection Packers. The diameter, depth, angle and spacing of the holes shall differ according to the nature of the damage causing the leak. Once the drilling of the holes is completed, they will be flushed out with compressed air and cleaned by the brush. The packers are inserted and fixed tightly to seal the drill holes effectively. In case of heavy water flow, pre-injection using injection foam shall be applied temporarily to reduce the water flow and facilitate further operation.

In order to set the suitable reaction for gel components, a small amount of gel shall be injected into a disposable clean cup to check and set the suitable reaction time. Once the set time is confirmed, gel injection shall be started using the air-compressed operated pump injection. Pump nozzle will be connected to each packer in sequence and the gel is injected through the drilled packers on the structure from inside to outside. The gel reacts with the water and binds it, resulting in a waterproof and elastic solid barrier on the external side. The injected material is dispersed on the exterior side and in a short time it reacts and creates a waterproofing curtain layer as detailed in the Figure.5 below. This results in the advantage that no water shall reach the injected building parts anymore and will be fully dried out. Several iterations might be required until the leakage is arrested permanently.

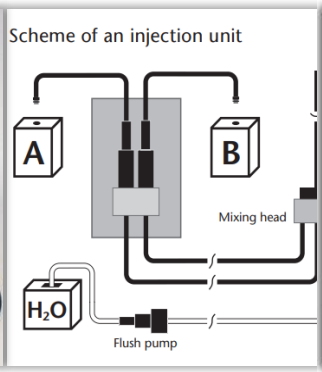


Figure 4: Two components air compressed operated Pump

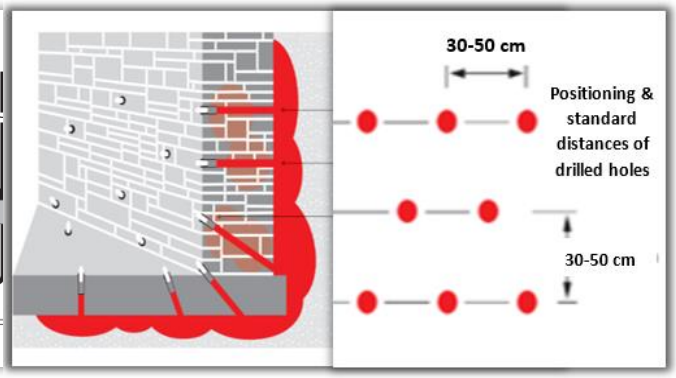


Figure 5: Injected gel creating curtain around the structure

❖ **Pipe Patching (Inflatable Packer System)**

Pipe Patching using Inflatable packers is considered as one of the most effective solutions for repairing the damage and leak in the pipe, where the structure is not easily accessible or unable to excavate the adjacent area (trenchless method) to reach the pipe damage. Usually, trenchless pipe repairing method aids in beginning the repair quickly and also minimizes the cost of repair works. One of the main limitations of the pipe patching method is that it can only be used for repairing the pipes without any services available within the pipe such as cables etc. However, the technology can be used for pipe repair works with the fluids available within the pipe, such as water supply and sewer networks.

In general, the main components of pipe patching system are inflatable packer, flexible air push bars with adaptors, air compressor, a glass fiber mat and resin as detailed in the Figure.6 below. Inflatable packer system can be used to repair a wide range of pipes made of concrete, asbestos cement, plastics (PVC, PP, HDPE), cast iron, ductile iron, reinforced concrete and vitrified clay. It is available with a wide range of inflatable, multi-sized packers for a particular point or sectional pipe repair. Moreover, it can also seal irregular or egg-shaped pipe sections from 0.5 to 5 meters in length. However, for longer sections, overlapping can be used. It is also applicable for repairing a variety of pipes with the diameter ranging from 35 mm to 1200 mm without replacing the underground pipes.

In brief, Pipe patching starts with preparing the lining over the inflatable packer, ensuring the minimum overlapping on both sides of the damaged section is identified already. Lining consists of a specially designed fiberglass mat impregnated with a strong resin. Directly, after installing the lining layers over the inflatable packer, it is inserted exactly to the underground pipe damaged point using the flexible air rods. Compressed air is applied to inflate the packer gradually thus, the packer expands towards the wall of the pipe and strongly presses the impregnated fiberglass mat in a tight fit against the host pipe with excessive reacting resin, penetrating into the damaged portion as detailed in Figure.7 below.

After the curing is completed, the lining resin creates a permanent bond between the fiber glass mat and the host pipe wall. The compressed air is then released and the deflated packer is removed as explained in the Figure.8 below. The lining covers the entire damaged area, additionally reinforcing the pipe and arresting the leak without obstructing the service flow. After strong bonding, the fiberglass lining shall handle extreme temperatures and pressures, making it an ideal solution for gravity sewer pipes and pressurized pipes.

Figure 6: Patching system components (Inflatable Packer, Flexible air push rods, glass mat and resin

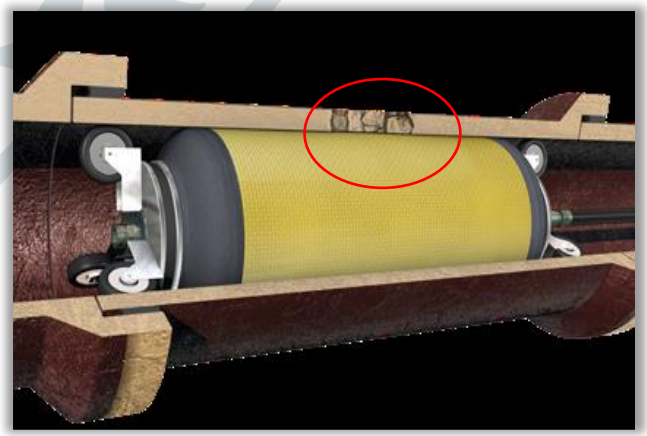

Figure 7: Inflated packer fixing the lining over the damaged section)

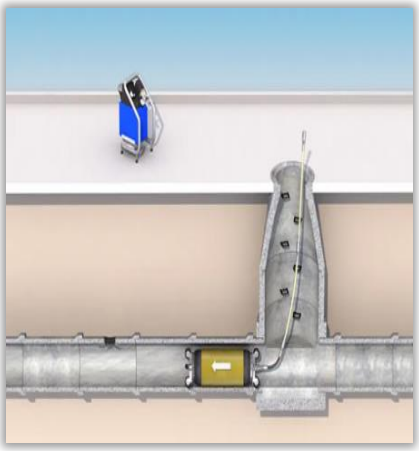

Figure 8a: Inflatable packer is carrying the lining to repair the leak on the damaged area

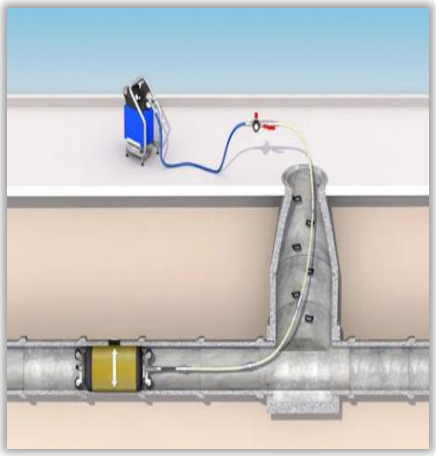

Figure 8b: Inflatable packer pressing and applying the lining on the damaged area

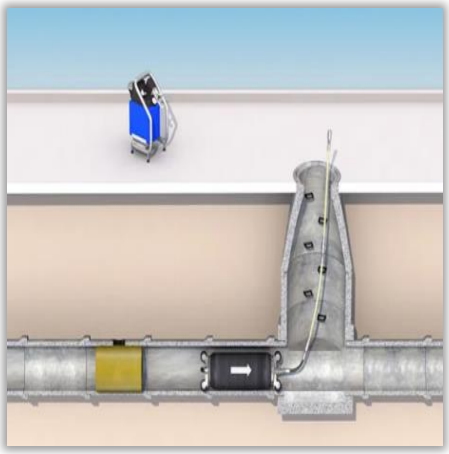

Figure 8c: Removing the Inflatable packer after lining is repaired and cured.

❖ **Mechanical Seal**

When the repairing and patching methods for the sleeves and ducts are failed and are unable to arrest the leak, the mechanical seal is the final and effective method for pipes, sleeves and ducts. A mechanical seal works as a permanent plug that ensure to hold the water inside the pipes, sleeves and ducts.

This is the very commonly used sealing method even as a proactive measure to arrest the water leak through the pipes, sleeves and cable ducts. Usually, the mechanical seals are provided at the entry point (inside face) of the pipes, sleeves and ducts in the substructure to prevent any leak to enter the structure. Ex. In the basement of any structures, all the cable and services entry pipes sleeves can be fixed with the mechanical seals to prevent the leakage.

These mechanical seals are incredibly user-friendly and can be relied upon for effective sealing. The biggest advantage is that these seals can be custom-made according to the requirement at the location and diameter of the pipe/sleeve/duct. Also these seals can accommodate multiple cables/services with limited various diameters that are passing through the sleeve and duct. They can be easily fixed even before and after the cables or services are installed, provided the appropriate type of seal is used. This technology provides the stoppage of leak inside the structure even if the leak is currently available inside within the sleeve or duct.

Mechanical seal comes with segmented ring technology for individual adjustment to cable/pipe diameters on site, mainly for sealing cables in core drill holes or wall sleeves. Split design seals can be used for sealing the entries with new cables to be installed or cables that have already been laid in the sleeve or duct by just splitting the required part of the mechanical seal. Whereas, the closed design mechanical seals can be used only before installing the cables / services in the sleeves and ducts, so that the cables/services to be laid are just passed through the holes that are readily available in the installed mechanical seal. There are bolts available in the seal which are used to loosen and tighten to closely fit and tight the cable/service that is passing through the seal. There are rubber layers at each hole in the seal to accommodate the service with the required diameter. These rubber layers can be removed or kept as such as per the requirement, to tightly seal the cable/service passing through the seal. The below figures are explaining the various types of mechanical seals.

Figure 9: Split type multi-cable sleeve with rubber layers and cables *passing*


Figure 10: Split type single cable sleeve

Figure11: No Cable – Non reusable future cable seal

Figure12: Closed type multiple cable sleeve for fixed diameter

Figure13: Seals for various sizes

**Conclusion:**

In conclusion, the repair and rehabilitation of water leaks in concrete structures is an important process that requires careful attention and expertise. Proper diagnosis of the cause of the leak, selection of the appropriate repair materials, and proper installation techniques are essential to ensure that the repair is successful and long-lasting. With the right approach and materials, the repair and rehabilitation of water leaks in concrete structures can be made successful and cost-effective.

This article provides the different methodologies of identification, detailed investigation and rectification to arrest the leakage in the structure. The repair and leak arresting are not limited only to the above explained, but there are also other various methods that are being followed in different projects which might suit specifically to each type of the structure and the problems with it. This article has detailed only the common practices of arresting the leaks, which are widely used in the construction field and can be suitable for all type of projects.

**REFERNCES**


- PU Combi Injection Resins. (2022, August 10). ©2022 WEBAC-Chemie GmbH. Retrieved December 23, 2022, from https://www.webac-grouts.com/solutions/classic-line/pu-combi-injection-resins/
- PU Injection Repair - Dry Proof Waterproofing, Singapore. (2020, March 15). Dry Proof Waterproofing. Retrieved December 23, 2022, from http://dryproof.com.sg/pu-injection-repair/
- Curtain Injection. (2022, August 10). ©2022 WEBAC-Chemie GmbH. Retrieved December 23, 2022, from https://www.webac-grouts.com/applications/classic-product-line/curtain-injection/
- Conmix. (n.d.). ReCon PU R Data SheetCC/RC15/Ver7/11/15 (Version Ver7) [Dataset].
- Hauff-Technik, H. (n.d.). Hauff-Technik - Cable entries, press seals, conduits, wastewater entries, multiple-service building entry systems or single building entries. Hauff-Technik. Retrieved December 23, 2022, from https://www.haufftechnik.ae/en/solutionworld/1/loadGroup/13?cHash=2bb6706accea5c7abdd1a98821d91034.
- Chemifix. (2015, January 7). CHEMIFIX Sealing Crack Injection [Video]. YouTube. https://www.youtube.com/watch?v=o_GUDdmLjMs
- Sectional pipe repair with short liners. (n.d.). Retrieved December 23, 2022, from https://www.trelleborg.com/en/seals-and-profiles/products-and-solutions/pipe-rehabilitation/method/trelleborg-short-liner-method
- How to Seal or Repair Cracks in Concrete Walls, Floors or Slabs. (n.d.). Retrieved December 23, 2022, from https://inspectapedia.com/structure/Concrete_Crack_Repairs_Sealants.php.