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Methods of Treatment for Concrete Substrate Preparation

Méthodes de traitement du béton

Methoden der Betonuntergrundvorbehandlung

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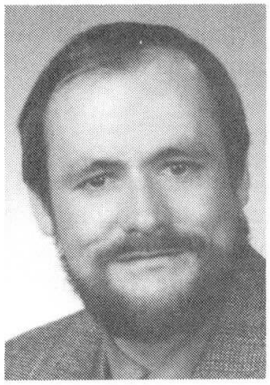

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SUMMARY

Different techniques can be used for concrete substrate preparation depending on the aim which has to be fulfilled. They can be subdivided into mechanical, thermal, and chemical techniques. All these different techniques have their special fields of application, advantages and disadvantages. They also differ in performance. The following article outlines the mechanisms of the main techniques for concrete substrate preparation as well as the advantages and disadvantages, the performance and costs of these techniques. These techniques are presented and the requirements for their application are given.

RÉSUMÉ

Il existe différentes techniques de traitement du béton. Le choix dépend des buts à atteindre. Il y a des procédés mécaniques, hydrodynamiques, thermiques et chimiques qui ont des domaines d'application particuliers et qui présentent des avantages et des désavantages. Leur efficacité est différente. L'article présente ces différentes techniques et leurs champs d'application.

ZUSAMMENFASSUNG

Es gibt eine Vielzahl unterschiedlicher Techniken zur Betonuntergrundvorbereitung. Die Auswahl richtet sich nach den zu erfüllenden Zielvorstellungen. Man unterscheidet mechanisch, hydrodynamisch, thermisch und chemisch arbeitende Verfahren. Alle diese Verfahren haben ihre speziellen Einsatzfelder sowie verfahrensspezifische Vor- und Nachteile. Sie unterscheiden sich auch in ihrer Leistungsfähigkeit. Der folgende Beitrag stellt die Wirkungsweise der gebräuchlichsten Techniken vor und geht auf deren Vor- und Nachteile sowie auf die Leistungsfähigkeiten ein. Einsatzfelder werden aufgezeigt.

1. INTRODUCTION

The preception of concrete as a building material has changed over the last decades, from concrete being viewed as a durable material requiring little maintenance, to the realisation that deterioration of concrete structures, such as concrete cancer, are serious problems requiring attention. The causes of concrete decay are manifold, ranging from errors in early design and detailing of the structure, to problems created during construction such as reinforcement being placed too close to the surface of the slab and finally environmental attack, such as chloride corrosion, which is a particulary significant problem in Germany. The imagery associated with concrete deterioration are now well known, rust appearing on the facade, cracking in the surface, shell shaped peeling and so on.

Repairing the deterioration of concrete buildings requires attention. Successful concrete repair needs to be carried out by experts from reliable companies experienced in the repair of concrete structures as repairing deterioration is usually more complex than constructing something new.

All methods of repair require the surface of the existing material to be prepared in order that the new material adheres successfully. Depending on the cause of the damage and the chosen method of repair, the existing surface will need to be treated by a combination of cleaning , roughening or removing material before the repair technique can be employed. The requirements to be fulfilled by the concrete surface before repairing measures can start are defined in [1] and [2].

2. CLEANING TECHNIQUES

Simply cleaning the existing surface may be sufficient if there is no structural damage to the existing concrete, for example, cleaning can be suitable preparation for the application of paint. Cleaning the surface does not remove any of the existing concrete from the structure, it only removes loose contamination such as layers of dirt, paint and coatings to an effective depth of 1 mm.

Conventional cleaning techniques include wire brushing by hand or machine, high pressure air blasting with oil-free air, water jetting, hot water jetting, steam jetting and treating the surface with chemical. High pressure water jetting is also effective in removing previous surface applications to concrete (Table 1).

3. METHODS FOR ROUGHENING

Techniques for roughening the surface of the concrete will also remove any loose or decayed concrete on the surface of the structure. The effective depth for roughening of the surface is approximately 3 mm, removing the cement skin. There are mechanical, hydrodynamical and thermal techniques available for treating the concrete surface.

One conventional mechanical technique is blasting the surface with solid agents. This can be done either dry or with the addition of a small amount of water against the dust. A vacuum system can also be adapted to remove the waste/blasting agent mixture from the process. The vacuum head is situated arround the blasting nozzle. A disadvatage of using an additional vacuum system is that the operator cannot observe the point where the blasting agent is hitting the concrete during the process and therefore the results are by the nature of the process approximate. The advantage of this method is that there is no dust appearing and disposal of the waste/blasting agent material is effective and the blasting agnet can be recycled and used again if desired. A better performance is achieved by using sand and water as the blasting agent. A problem can be the amount of

remains after blasting. The disposal of the water/abrasive mixture which also can be contaminated is always a problem.

The high-pressure water jet technique for roughening concrete is especially suitable for this purpose, using water pressures up to 250 MPa with a waterflow of up to 30 liter per minute. The waterjet is applied to the surface using a rotating nozzle. A high pressure water jet technique, combined with a vacuum system is in use and effective in removing waste material.

The flame treatment, used for removing dirt and surface applications is another popular technique. The maximum effective depth of this technique is 3 mm. Hand torches for vertical surface treatment and machine driven torches for horizontal surface treatment are in use. To use the technique a certain thickness of the concrete cover is needed to make sure that there will be no damage of the reinforcement. After using the flame technique, a mechanical treatment is required, such as wire brushing or blasting using steel balls as an abrasive (Table 1).

4. TECHNIQUES FOR CONCRETE REMOVAL

The field of concrete removal can be subdivided into planar removal and straight line removal or cutting. The removal depth can be varied depending on the requirement. Technuiques for concrete cutting include,
- chipping/caulking and sawing,
- high-pressure water jetting,
- high-pressure water jetting by use of additional abrasives.

Techniques for planar removal include,
- chipping/caulking, hammering, grinding and milling,
- high-pressure water jetting,
- high-pressure water jetting using additional abrasives.

Whilst flat peeling concrete it is essential to ensure that no additional damage is done to the surface and the structure other than what is desired. The stress of a jack hammer or miller on the surface may result in substructure cracking. Using any of these techniques requires a secondary treatment in order to adequately prepare the surface. This aftertreatment can be done by brushing machines, blasting with solid agents like sandblasting or water jetting. The risk of causing substructure damage is reduced considerably when hydrodemolition techniques are used for concrete removal. Hydrodemolition techniques treat the remaining material gentle. This principle was illustrated by SILFWERBRAND [3] when he compared different techniques for removing concrete.

Removing damaged concrete using the water jet technique has the advantage of only removing the concrete that has deteriorated, leaving the remaining material intact. Also the reinforcement remains intact. In addition, the surface of the structure after water jetting is ideal for the majority of repair techniques. Hydrodemolition techniques can be subdivided into two main machine types:
- systems working with a water pressure of 80 up to 120MPa using a waterflow of up to 300 litres per minute and
- systems working with a water pressure of up to 250MPa using a waterflow of max 30 litres per minute.

Advantages of the 80/120MPa systems are simplicity of construction, low maintenance and technical faults are not common. There are no special requirements concerning water quality and therefore filtered river water or recycled water from the water jetting process is acceptable. The disadvantage of this system is the high quantity of water required for the process and as a result, disposal of such a large quantity of water can be difficult considering that now water must be cleaned and recycled. A number of robotic water-jetting units, power guided systems are on the market which are able to remove 10 cm concrete surface in one go.

Regarding the problems with the wastewater, there are less problems by using the 250MPa systems. The maximum waterflow of these systems is 30 l/min. Therefore these systems are used for high rise structures where a huge amount of wastewater would be an additional problem. Any water running down the facade must be catched up and cleaned before it can be put into the sewage canal. It is also easy to handle a manual guided jet pistol on scaffolding. However, these machines are highly sophisticated and therefore require a lot more servicing than the 80/120MPa machines. The 250Mpa machines also require a high quality of the water. The water must be thoroughly clean without any impurities, in fact, cleaner than drinking water. Especially no suspended particles are allowed to be in the water. Typical uses for this system are cleaning and roughening of the surface using a rotating nozzle beam or removing concrete from reinforcing by using a hand manipulated jet pistol. This also removes the rust from the steel. This system can also be used to cut concrete. Table 1 is an overview of the different techniques available for concrete removal, roughening and cleaning.

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Method	Application	Requirements/Restrictions	Assessment
Chipping: Maually by hammer and chisel, jackhammer	(2), (3) Local for small areas	Danger of deeper damage caused by shocks and vibration. Danger of damaged reinforcement after chipping because of sharp tool. Special care with stressing tendons.	Low expenditure of machinery, can be used also for work in vertical and overhead position, low performance, dust, noisy.
Hammering: Needle gun	(1), (2), (4) Local for small areas		Low expenditure of machinery, can be used also for work in vertical and overhead position, low performance, dust, noisy.
Hammering: Mechanical hammer	(1), (2), (3) Depending on the size of the machine local or wide-area	Danger of deeper damage caused by shocks and vibration. Danger of damaged reinforcement after hammering because of sharp tool. Special care with stressing tendons. It is not possible to expose reinforcement.	Low expenditure of machinery, can be used for work in horizontal position only, dust, noisy.
Milling: Miller	(1), (2), (3) Wide-area removal from any even horizontal surface. Local removal from any even surface.	Concrete removal in each pass ≤ 5 mm, use of electronic levelling instruments nessecary for working on wide areas. It is not possible to expose reinforcement.	Often used technique for concrete removal from wide areas, noisy.

Table 1.1 Techniques for surface treatment (after [1] [2]).

Method	Application	Requirements/Restrictions	Assessment
Grinding: Grinder	(1), (2), (4) Local		Low expenditure of machinery, low performance, dust, noisy.
Brushing: Wire brushing with rotating brushes or brushing machines	(1), (2), (4) Local	After treatment for different techniques for surface preparation.	Low expenditure of machinery, low performance, dust, noisy.
Blasting with steel balls	(1), (2) Wide-area roughening of even horizontal or slightly sloping surface, local roughening of any even surface.	Can only be used on even surface.	Good for removing of coatings, possible aftertreatment after flame treatment.
Blasting with compressed air:			
Free blasting with solid agents (sandblasting)	(1), (2), (4) universal technique for local and wide-area use.	The removal depth is caused by the kind of abrasive, its size, its amount and the air pressure. Enormous appearance of dust, special regulations about dangerous goods need to be observed. The compressed air needs to be oil-free and water-free.	Universal, sufficient removal of rust from reinforcement, high performance, low costs, dust (housing necessary).
Dry blasting dustfree (suction apparatus)	(1), (2), (4) Local	The removal depth is caused by the kind of abrasive, its size, its amount and the air pressure. The compressed air needs to be oil-free and water-free	Sufficient removal of rust from reinforcement, low performance, recycling of abrasive possible.
Water-spray blasting dustfree	(1), (2), (4) Local and wide-area	The removal depth is caused by the kind of abrasive, its size, its amount and the air pressure. The compressed air needs to be oil-free. Cleaning of the surface after treatment necessary.	Suitable if requirements for low dust appearance are to be met, sufficient removal of rust from reinforcement but new rust appearing after treatment
Pressure (high-pressure) water blasting with water/abrasive mix	(1), (2), (3), (4) Local and wide-area	The removal depth is caused by the kind of abrasive and the water pressure. Cleaning of the surface after treatment necessary.	High performance, sufficient removal of rust from reinforcement but new rust appearing after treatment
Blasting with pressure water with or without suction of the blasting water and waste material	Local and wide-area	Appearance of huge amount of wastewater which needs to be disposed or recycled.	
< 20 MPa (40 MPa)	(1), (5) Surface cleaning	The cleaning result depends on the water pressure, water temperature, kind of nozzle and distance between surface and nozzle.	Disposal of wastewater necessary.

Table 1.2 Techniques for surface treatment (after [1] [2]).

Method	Application	Requirements/Restrictions	Assessment
40 - 120 MPa (high-pressure range)	(1), (2), (3), (4) Power guided device (robotic systems): wide-area, removal and roughening Manual guided tools: local	The removal depth depends on the water pressure, waterflow, duration and distance between nozzle and surface, uses an enormous amount of water up to 300 l/min.	Disposal of wastewater necessary, use of recycled water possible, above 100MPa, sufficient removal of rust from reinforcement but new rust will appear after treatment, noisy.
> 120 MPa (highest-pressure range) suction of water and waste material possible	(1), (2), (3), (4), (5) Power guided device: wide-area, removal, roughening and cleaning, Manual guided tools (jet pistols): local for concrete cutting	The removal depth depends on the water pressure, waterflow, duration and distance between nozzle and surface, waterflow up to 30 l/min.	Highly sophisticated technique, disposal of waste-water necessary, use of recycled water yet not possible, sufficient removal of rust from reinforcement but new rust will appear after treatment, noisy.
Flame treatment: Hand torch Machine driven torch	(1), (2) Wide-area roughening of even horizontal or slightly sloping surface, local roughening of any even surface.	Specially trained operators necessary. DVS guidelines 0302, min. speed and concrete cover. Removal up to 3 mm. It is not possible to expose reinforcement. After treatment with wire brushing or blasting with solid agent is nessecary.	Low expenditure of machinery, high performance.
Cleaning:			
Blowing	(5) Not horizontal areas	Compressed air oil-free.	Dust
Suction: Industrial vacuum cleaner	(5) Wide horizontal areas	Normal treatment before applying repair mortar or coating.	
Water jet Steam jet Hot water jet with or without chemical additives	(1), (5) Removal of dirt and loose contamination	Regulations for waste disposal need to be observed.	Disposal of wastewater necessary and possibly difficult.

Applications:

(1) = Removing of old coatings, after-treatment applications, surface contamination.
(2) = Removing of low-strength layers and cement skin.
(3) = Removing of damaged concrete and concrete repair material and exposing reinforcement.
(4) = Removing of rust from exposed reinforcement.
(5) = Cleaning off loose contamination, dust, loose material and water films.

Note:

"Compressed air oil-free" means, air with ≤ 0,01 ppm residual oil.

Table 1.3 Techniques for surface treatment (after [1] [2]).