



## **WORK GUIDELINE No. 1**

Removal of concrete by high-pressure water-jet,  
mechanically powered or hand operating tools

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# 1 Purpose and scope

## 1.1 Purpose

The present guideline defines conditions and methods for removal of degraded concrete by high-pressure water-jet (900 – 1,500 bar), electrical and pneumatic hammers in areas where the use of water-jet technique is not convenient or not permitted because of the presence of electric cables.

## 1.2 Scope

Concrete removal depth is different in regard to the concrete decay, and comprises surface removal of cement laitance up to concrete removal to a substantial depth, or breaking through reinforced concrete structural members.

Loose concrete shall be removed up to a sound and solid concrete surface in areas of corrosion centres, of chloride contamination, of major porosity or poor compactness and of concrete lamination, as well as in areas damaged by frost, where the concrete has lost its alkalinity and its corrosion protective function and in all the areas where additional casting or application of mortars is foreseen thus requiring a minimum necessary adhesion to the substrate (adhesive strength) of 1.5 N/mm<sup>2</sup>.

# 2 Reference documents

Technical instructions by high-pressure water pump manufacturer;  
Bridge rehabilitation design;  
Report on detailed bridge inspection.

# 3 Preliminary conditions

Before removing concrete by a high-pressure water-jet the following conditions shall be fulfilled:

- The Contractor shall be fully equipped and expert to perform this type of works;
- All the surfaces where concrete has to be removed shall be marked with regard to the damage rate and to the required depth of removal;
- The Contractor shall take into account the technology requirements related to both quality and depth of concrete removal. He shall also consider further work methods to achieve a surface structure where individual mineral aggregate grains stick out from the concrete surface, i.e. they are free of hydrated cement paste;
- Taking into account the fact that concrete surface visibility is poor at the vicinity of concrete removal place, constant parameters shall be ensured during these works: water-jet pressure, distance from the concrete, water gun moving speed (a robot is recommended);
- During the use of a high-pressure water pump all the necessary safety precautions shall be taken to protect both humans and environment;
- The contractor shall keep in stock at least one set of essential mechanical spare parts for the high-pressure water pump and for other equipment to avoid unnecessary work interruptions.

## **4 Safety requirements and restrictions**

Removal of concrete using high-pressure water-jet may only be carried out from perfectly safe scaffoldings equipped with a protective railing to prevent workers from falling in case of poor visibility resulting from the mist due to the water-jet, or of an uncontrolled step.

Protection from particles flying away due to high-pressure water-jet application shall be ensured.

When concrete is removed by high-pressure water-jet close to a railway track with high-voltage overhead wiring, the minimum required distance from this power wiring shall be fully considered. Such a distance shall be marked with a red flag. Immediately above the railway track, concrete shall be removed mechanically, i.e. using hammers, without any water-jet.

### **4.1 Personnel**

Removal of concrete by water-jet or manual tools may only be executed by skilled manpower preliminarily trained on safety at work and on technological requirements.

### **4.2 Equipment**

All equipment such as high-pressure water-jet devices, electric and pneumatic pounding hammers, as well as fixed, mobile, and suspension scaffoldings shall meet all the safety requirements, which shall be inspected and approved by the safety engineer.

Power supply cables shall be adequately placed as not to impede the works.

## **5 Instructions for concrete removal**

The required depth of concrete removal depends on the concrete damage rate, depth of corrosion centres, depth of concrete chloride contamination, depth of concrete carbonation, depth of concrete lamination and foreseen additional concrete casting. On the basis of visual findings, measurements of concrete chloride content and concrete carbonation depth, corrective measures in the sense of concrete removal up to the required depth, i.e. a sound and solid structure, uncontaminated concrete structure, shall be carried through.

### **5.1 Areas of corrosion centres**

In areas where:

- corrosion centres are identified on the concrete surface,
- corroded reinforcement is visible,
- the concrete above reinforcement is partially moved away,
- brown stains due to reinforcement corrosion are noticed on the concrete surface and cracks above the reinforcement location have occurred, the concrete shall be removed along the reinforcement up to the area of non-corroded reinforcement and at least 2 cm. behind the corroded reinforcement to allow its blast cleaning to the SA 2 ½ degree also behind.

- prestressed tendons are damaged or even corroded-through, the concrete shall be removed to such an extent as to allow the access to the area of non-corroded tendons, and to the area of admissible chloride content respectively (for concrete 0.4% by weight, and for grouting compound 0.1% by weight in relation to cement).  
In case that the grouting compound within the tendons is contaminated with chlorides above the admissible value of 0.1% by weight, it shall be removed exclusively by of a high-pressure water-jet, as the removal using pounding hammers might damage the tendons.

## **5.2 Concrete removal by electric and pneumatic hammers**

In areas where high-voltage power installation are in close vicinity, the concrete must not be removed by a high-pressure water-jet. In case of minor local damages, electric or pneumatic hammers might be used.

The hammer point must not pound directly at the steel reinforcement, as micro-cracks might occur in the sound concrete.

## **6 Washing sound reinforced concrete surfaces**

All the undamaged surfaces of bridge reinforced concrete structural members to be protected by suitable coatings shall be washed by water-jet at 400 bar of pressure. All dirt, moss and loose material shall be removed from the surface. In areas of porous surface the cement laitance shall be removed to make mineral aggregate grains visible. Surfaces with calcareous deposits shall be cleaned manually.

## **7 Suitability criteria**

The concrete may be considered as removed in a sufficient thickness and to an adequate extent when the following criteria are fulfilled:

- The weight content of water-soluble chlorides in the concrete surface layer after removal of contaminated concrete shall not exceed 0.4% of cement weight.
- After removal of contaminated concrete the pH-value on the concrete surface shall be higher than 11.5 (Phenolphthalein Test).
- In areas of corrosion centres the concrete surrounding corroded reinforcement shall be removed as to achieve a minimum void of 2 cm. behind the reinforcement in the longitudinal direction; transversely, the concrete shall be removed up to the area of non-corroded reinforcement.
- In segregated areas, or where concrete lamination has taken place, the concrete shall be removed up to a sound and solid structure.

### **7.1 Taking-over of surfaces**

After the removal of concrete, and prior to further surface treatment, the surfaces shall be taken-over and recorded in a protocol.