

# Performance of the Cement-Based Mortars for Repairing the Internal Lining of Steel Pipes for Drinking Water Supplying

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## INTRODUCTION

The common pathology oftenly observed in the water-supplying steel pipes is cracking and delaminating the cement based internal lining [1]. Thus, the quick in-situ repair of these defects is essential for preventing the possible steel corrosion in pipes [2-4]. The implemented repair mortar must meet the sanitary norms regarding the chemical composition of the materials allowed to be in contact with drinking water [5]. The criteria of the physical and mechanical properties of fresh and hardened lining mortar have been set based on the relevant international and national specifications

## RESULTS

The current research was carried out in WGAC in collaboration with Mekorot – Israel National Water Co., during 2015 – 2017. The aim of the research was to reveal the most appropriate compositions of the cement-based mortars for the in-situ repair of internal lining of steel pipes.

The research program was based on:

- investigation of the physical and mechanical properties of 23 fresh and hardened “in-situ prepared” (18 mortars) and “ready-mix” (5 mortars) compositions (Figs 1, 2);
- preparing the special models of the cement-based lining implemented on the steel plates (Fig. 3);
- study of the adhesion strength of cement-based lining implemented in the models, as a function of:
  - mortar composition (the type of chemical admixture and the granulometric composition of sands) and physical properties of the fresh mortars;
  - specific environmental exposure of lining mortars before their implementation on the steel plates;
  - type of the surface preparation of steel plates before the implementation of cement-based lining;
  - characteristics of the environmental exposure (different temperatures and relative humidity (ca. 55%RH & 100%RH) to which the lined steel plates were subjected for 3 to 9 months, in laboratory conditions, as well as in-situ, inside the functioning pipe line (Figs 4, 5).



Figure 1. Samples used in the tests of physical and mechanical properties of hardened mortars

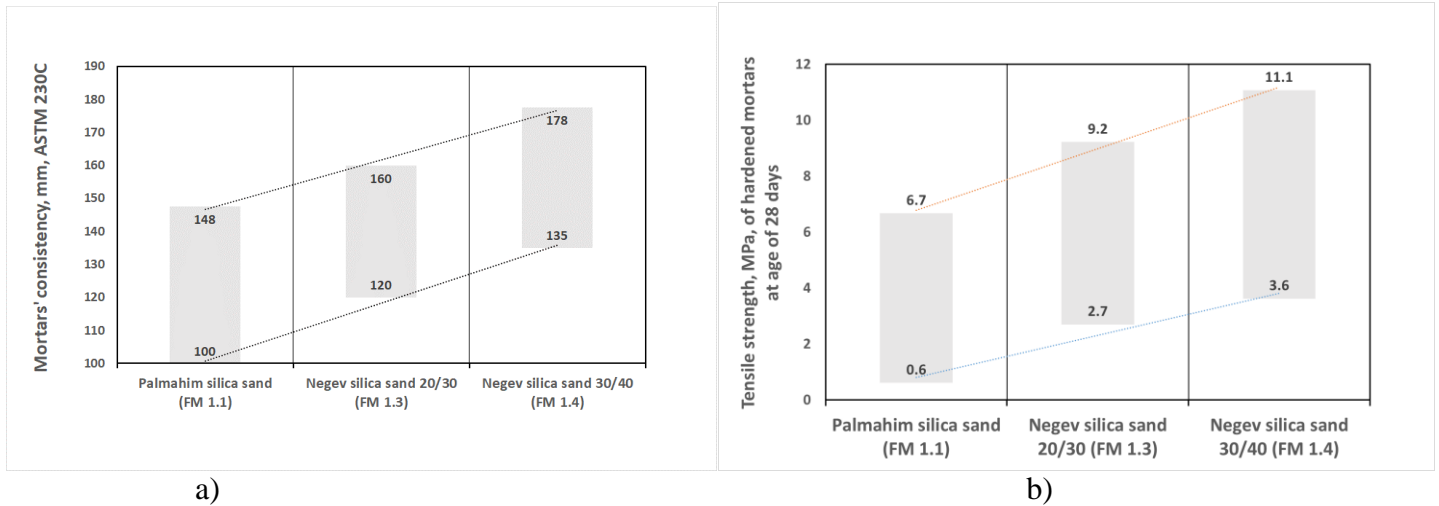


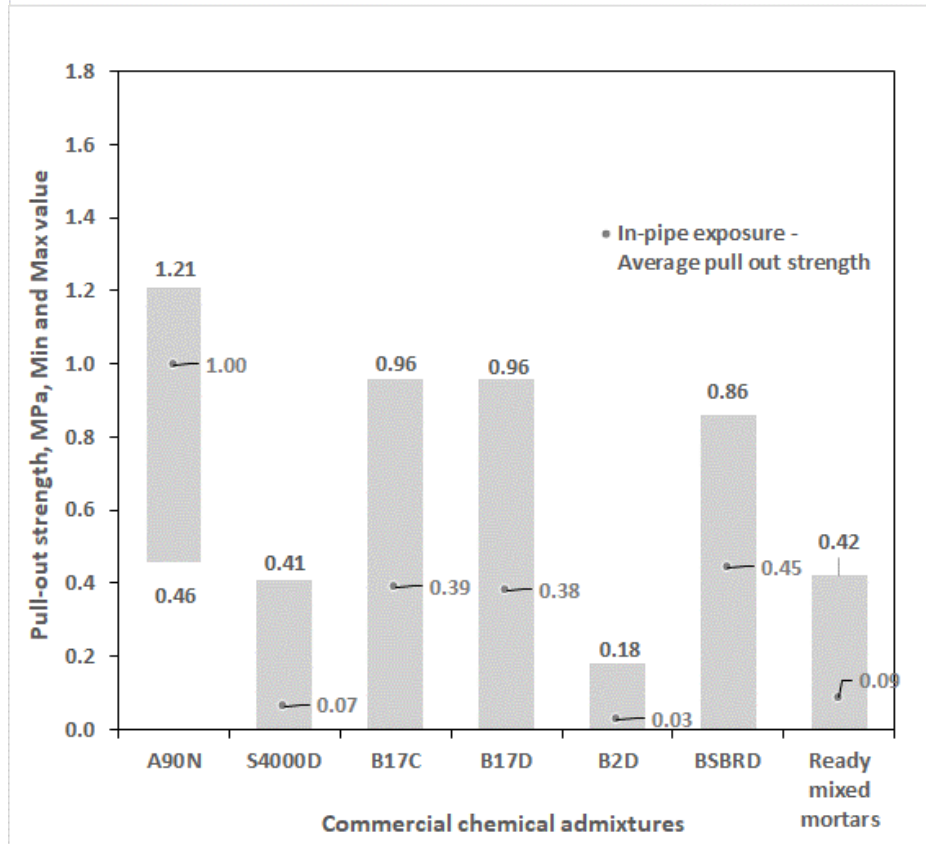
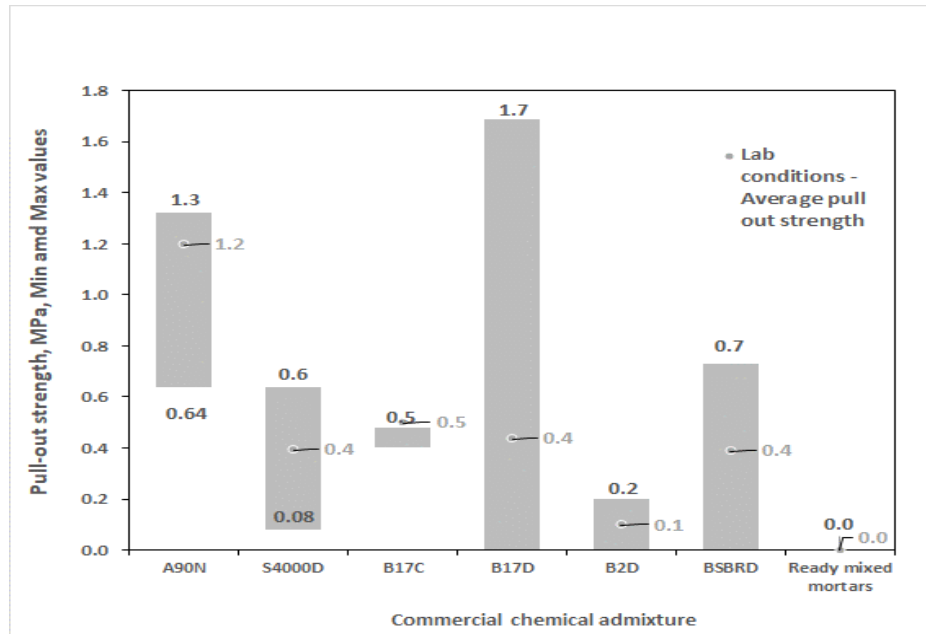
Fig 2. Effect of sand properties on the properties of in-situ prepared mortars; a) consistency range of fresh mortar; b) tensile strength of hardened mortar. FM – fineness modulus



Figure 3. Special models of the cement-based lining implemented on the steel plates



Figure 4. In-situ exposure of the cement based lining conditions inside the functioning water-supplying



a)

b)

Fig 5. Effect of commercial chemical admixture on pull out strength of ctmnt-based lining; a) exposure to lab conditions; b) in-pipe exposure

The final criteria which were preliminary set basing on the relevant international and national specifications, were tested and reset. These criteria have been:

- the fresh mortar consistency measured at temperature  $21\pm 3^{\circ}\text{C}$  and  $55\pm 5\%$  RH should be 160 – 180 mm;
- the mortars should keep almost the same consistency when exposed to the hot environment ( $34\pm 1^{\circ}\text{C}$ ) for 60 minutes, at least. This criterion could be met by keeping the content of the solids in the commercial chemical admixture used in the mortar mix, as high as 45% (by mass), at least;
- it was revealed that only the mortars which were characterized in the hardened state (at age of 28 days) by the oven-dried bulk density of more than  $1,970\text{ kg/m}^3$  have the appropriate strength characteristics and the required performance in-situ;
- the strength characteristics of the hardened cement-based lining mortars at age of 28 days should be:
  - compressive strength – at least 30 MPa;
  - tensile strength – at least 5 MPa.
- the adhesive ability of lining made of the cement-based mortars to steel background should meet the criteria of pull-out strength of 1.0 MPa, at least, whereas this value is mandatory after the exposure of cement-based lining to any service conditions occurred in water-supplying stainless-steel pipes.

## CONCLUSIONS

The research resulted in checking the criteria set by the valid international specifications for cement-based internal lining used in the water supplying steel pipes, resetting the most important criteria in order to obtain the highly performing internal lining and finding out the cement-based mortar compositions meeting these criteria.

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