TUNNEL SHOTCRETE LINING FOR HYDROELECTRIC PROJECTS IN BRITISH COLUMBIA, CANADA

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In British Columbia (BC), Canada, the primary source of power supply is hydroelectricity. The BC government, through its crown corporation, BC Hydro, has been working with private companies to provide sustainable and renewable energy. Private companies are building hydroelectric projects throughout the province of BC. Innergex has been constructing three hydroelectric projects; two are in the Upper Lilllooet area, which is about 250 km north of Vancouver and 80km north of Whistler and the third is in the Big Silver area, which is about 250 km east of Vancouver and 50 km north of Harrison Lake. All of these tunnels are hard rock and have been constructed by the drill and blast method. At the beginning of the projects, dry-mix shotcrete was applied based on the contractor's previous underground project experience. Wet-mix shotcrete was subsequently introduced as a trial method. The contractor was impressed with its productivity and performance and consequently adopted it as the primary shotcrete placement method. Dry-mix steel fiber reinforced shotcrete continued to be used for special ground conditions. The construction schedule was reduced significantly by using wet-mix shotcrete, with resultant substantial cost savings.

The wet-mix shotcrete was initially reinforced with wire mesh and hand-applied. Shortly after, the tunnel lining method was changed to the use of robotic sprayed macrosynthetic fiber reinforced wet-mix shotcrete. A silica fume modified shotcrete mixture was designed and trial shot. Tests results met the project specification requirements for tunnel construction. The wet-mix macrosynthetic fiber reinforced shotcrete was placed, since July 2013, using pre-bagged materials supplied from Vancouver and mixed on site. Later, the contractor set up a dry-batch concrete batch plant on site and started batching shotcrete using local aggregates. The shotcrete mixture was qualified for use on the project by testing for compressive strength, boiled absorption and volume of permeable voids, and flexural toughness based on use of the round determinate panel to ASTM C1550. The effect on shotcrete performance of different addition rates of alkali-free accelerator was tested in trials. An addition rate of 6% alkali-free accelerator by mass of cement was selected and used.

Shotcrete nozzlemen were trained with a specially designed shotcrete training program. All shotcrete nozzlemen were qualified to shoot a basic Level I, and a more challenging Level II, for shotcrete with reinforcing steel or lattice girders. The construction quality control tests results for the project from August 2013 to December 2016 demonstrated that the shotcrete quality consistently met the project specification requirements. The projects were completed ahead of schedule because of productivity gains achieved from using wet-mix macrosynthetic fiber reinforced shotcrete. The contractors developed proper skills and techniques for application of wet-mix macrosynthetic fiber reinforced shotcrete applied by robotic sprayers with zero safety incidents or accidents.