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" EXPERIMENTAL STUDY ON DURABILITY PERFORMANCE OF PRECAST TUNNEL LININGS"

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ABSTRACT

Tunnels play an important part in the movement of people, goods, and special services. The structural and longevity performance of a tunnel's liner system—which may be precast, cast in place, or concrete using regular concrete, Geopolymer-based concrete, steel fibre reinforced concrete, and other materials—determines the utility of the tunnel. In the case of submerged tunnels, ground water levels, difficult geotechnical environments, and heavy overburden pressures, tunnel lining systems serve as the first line of defense. Precast concrete tunnel linings (PCTLs) are being used more frequently because their construction process is quicker and more affordable than the more conventional cast-in-situ lining practice. greater porosity and calcium ion leakage led to the formation of cubical chloro-aluminate crystals and a net loss of mass in both the RC and SFRC specimens after 8 months of Cl exposure.Exposure duration and chloride ion content both contributed to greater mass loss in exposed steel rebar.Compressive, tensile, bending, and rebar binding strengths were all increased in RC specimens subjected to 3.5% and 10% Cl because of the rapid precipitation of cementitious materials and the filling of micro-pores with salt crystals.

Key Words: *Concrete, Steel fibre reinforced concrete, PCTLs.*

I. Introduction

The confined entry ways with vehicles or subways access that is limited to apertures regardless of building types and construction techniques" are the terms used to describe tunnels. This definition does not include structures that act as bridges over tunneled highways, subways, or railways. Hung and Co., 2009). In order to make way for existing roadways, subways, or railways, road tunnel construction is mostly required to get around physical barriers like mountains or bodies of water. Hung and Co., 2009). Tunnels reduce traffic congestion significantly, which improves other indicators of environmental quality like noise and air pollution. In addition, tunnels open the way for environmentally friendly and long-lasting municipal infrastructures by effectively preserving outdoor habitats, cultural heritage, and historical structures. Hung and Co., 2009). interiors of passageways

Its liner systems are an important component of tunnel construction because they serve as the tunnel's internal support, absorbing the weight of traffic and ensuring the safety of those who use the tunnels. The passages' functionality is heavily dependent on the liner system's structural and life performance. Tunnel linings are designed to withstand extreme conditions, such as heavy rock loads, water barriers, and difficult geological surroundings. The conventional in-situ liner technique has been replaced in passageways by PCTL because of how quickly, securely, effectively, and affordably it can be applied. As this piece progresses, it becomes clear that PCTL segments can be used as both an initial and final reinforcement against large overload loads, as well as numerous other kinds of loads. They can be used

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on both gentle and solid ground with ease.

The liner of a tunnel bored by a TBM is usually constructed in segments that, when put together, form the concentric circles of the tunnel. The number of tunnel segments required to construct a complete tunnel circuit or circular is determined by a number of variables, including tunnel diameter, total weights to be carried, tunnel boring machine (TBM) model, and builder choice. Pieces of PCTL can weigh up to 16 metric tons and have dimensions of 1000 millimeters (40 inches) in width by 1500 millimeters (60 inches) in length.

II. EXPERIMENTS

Durability Performance Of Tunnel Lining Segments

Durability tests were conducted on cylindrical cores and sawed beam specimens retrieved from full-scale RC and SFRC lining segments. Furthermore, UHPFRC specimens were cast in the laboratory and evaluated for their chloride ions penetration resistance and mechanical

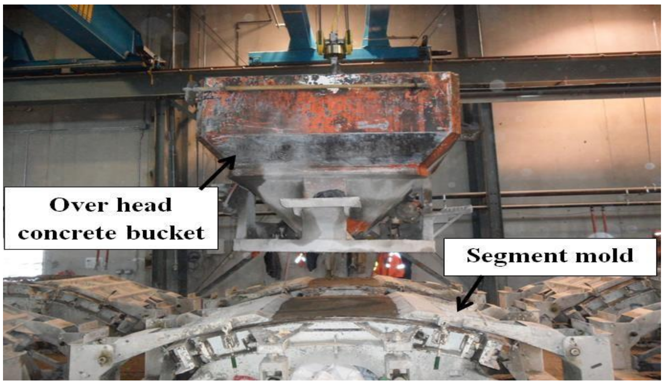

Figure1 – Concrete pouring into the segment mold using overhead bucket crane atprecast plant.

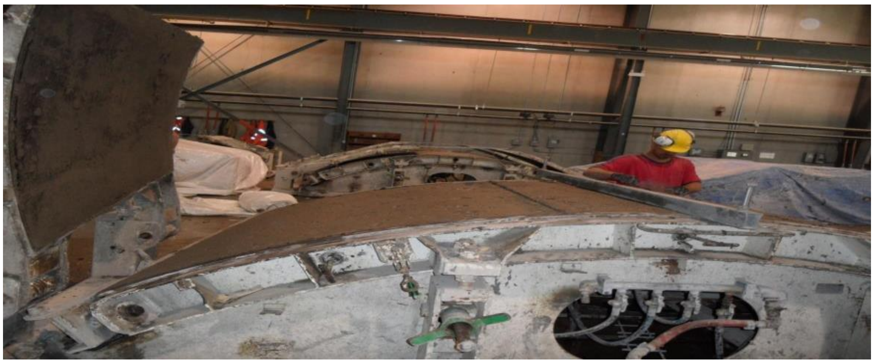

Figure.2 – Demolding process of PCTL segment at fabrication plant

Figure .3 – Another view for experimental setup *for flexural testing of lining Segment*

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Figure .4– Cracking in SFRC lining segments.

Figure .5 – Another view for experimental setup for punching test of lining segment

Figure.6 – Scanning electron microscope apparatus.

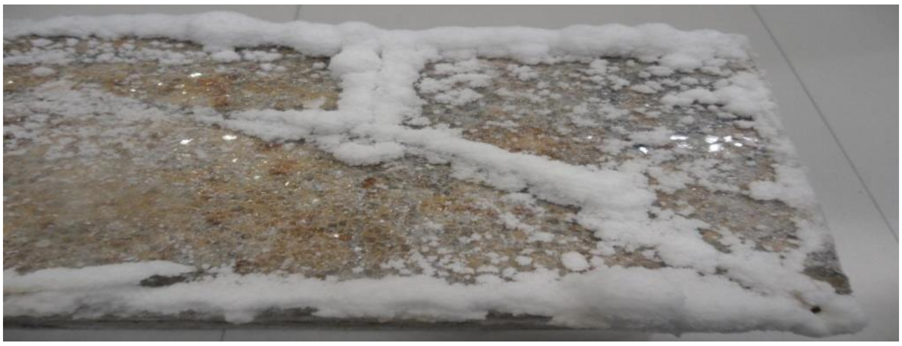

Figure.7– Salt deposition on beam specimens after chloride exposure.

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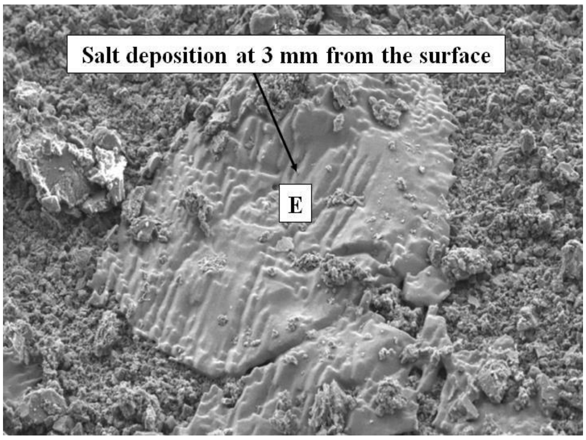
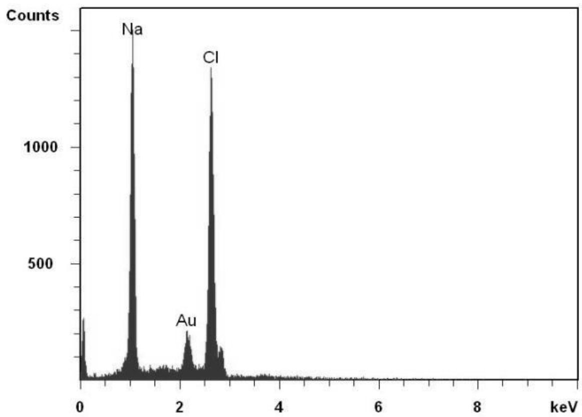
a) Corrosion signs on concrete b) Rebar corrosion

Figure.8– Corrosion of rebar after exposure to chloride solution





a) Chloride penereation inside concrete specimen b) EDX analysis at "E"

Figure. 9 – Chloride penetration inside the hardened concrete specimen confimed through scanning electron microscopy analysis.

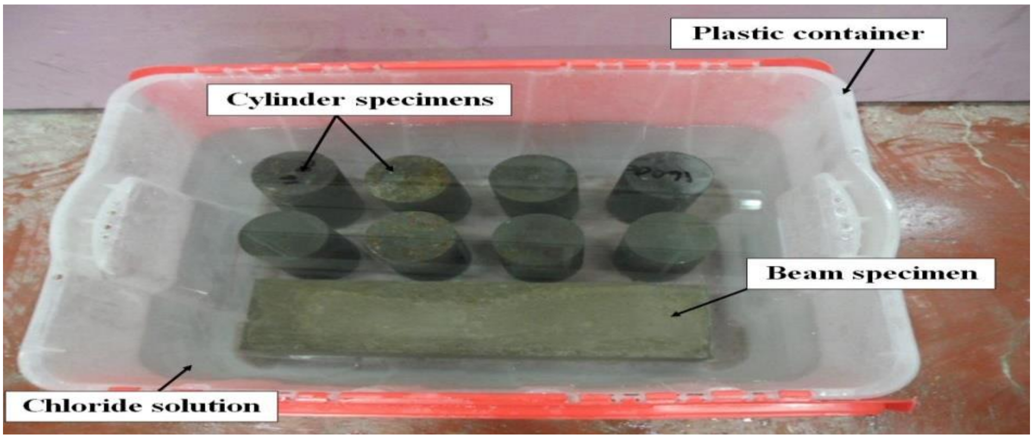


Figure. 10 – Salt immersion test for UHPFRC

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III. Results & Discussion

Degradation under various chloride exposure conditions. The following specific conclusions can be drawn from this study:

• SFRC specimens exhibited lower initial and secondary sorptivity coefficient for both the external (intrados and extrados faces) and internal (middle) specimens, compared to that of RC specimens.

• SFRC specimens showed lower Cl penetration at each depth and exhibited lower chloride diffusion coefficient compared to that of the RC specimens. Furthermore, it was observed that the chloride diffusion coefficient decreased as the exposure age/period increased.

• SFRC specimens exhibited lower coulomb values using the ASTM C1202 RCPT test compared to that of RC specimens for both the external and internal specimens at all exposure solutions (i.e. 3%, 3.5% and 10%).

• SFRC specimens showed surface corrosion of steel fibres. However, no signs of corrosion on embedded steel fibres were observed even after 16 months of accelerated Cl exposure, which was confirmed through SEM and optical microscope analysis. Furthermore, no concrete spalling, chipping or bursting was observed due to corrosion of fibres in SFRC specimens. On the other hand, significant surface degradation including crack development was observed in RC specimens.

• Test results on bare steel rebar showed that the rebar mass loss increased as the concentration of chloride ions and exposure period increased.

• Initially, an increase in mechanical properties was observed for RC specimens for both the 3.5% and 10% Cl exposure. This was attributed to the advancing hydration of cement and filling of micro-pores with salt crystals. However, after 8 months of Cl exposure, a reduction in strength properties was observed for RC specimens. This was attributed to mass loss due to leaching of calcium ions and formation of chloro-aluminate crystals, leading to increased porosity. Conversely, SFRC showed no reduction in mechanical properties after 16 months of Cl exposure. Interestingly, a progressive increase in SFRC strength properties was observed with increased Cl exposure duration.

• An increase in rebar bond strength was observed at early-age (up to 8 months) of Cl exposure due to increased strength properties of concrete and increased friction at the rebar interface due to initial formation of corrosion products. However, at later ages (12 months or more) of Cl exposure, more formation of corrosion products at the rebar surface weakened the contact between steel and concrete, thus leading to reducing the bond strength.

• The service life of conventional RC and SFRC PCTL segments was estimated based on the chloride diffusion coefficient and concrete resistivity properties. It was found that SFRC segments can exhibit higher service life when subjected to corrosive environments compared to that of similar RC segments. Moreover, it was concluded that higher Cl concentration has adverse effects on the service lives of PCTL segments.

• It was observed that the UHPFRC tunnel lining segments exhibited enhanced durability properties compared to that of conventional RC and SFRC lining segments. This was attributed to its denser micro-structure and stronger bond between the aggregates, cementitious material and steel fibres, which was confirmed through SEM analysis. Furthermore, no degradation in UHPFRC mechanical properties was observed after exposure to various corrosive environments. Based on the structural and durability results of the tested precast tunnel lining segments, it can be concluded that UHPFRC has a great potential for the industrial fabrication of PCTL segments compared to that of conventional RC and SFRC. UHPFRC is an attractive option for the complete substitution of conventional reinforcing steel rebar cages in PCTL segments, leading to more economical and sustainable tunnel construction. This study made

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an effort to provide a confidence level to tunneling stakeholders in order to tackle this issue of costly corrosion deterioration in conventional RC segments by utilizing UHPFRC taking into account the following recommendations

IV. Conclusion

In the present thesis, full-scale tests were conducted on conventional steel rebar reinforced and steel fibre-reinforced PCTL segments in order to evaluate their mechanical behaviour. Therefore, the combined effect of conventional steel rebar and steel fibre reinforcements with various dosages in full-scale tunnel lining segments. The durability properties of tunnel lining segments were experimentally evaluated in the current thesis. A detailed numerical analysis is required in order to evaluate and verify the chloride diffusion coefficients and mechanical degradation of lining segments under various corrosive environments.

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