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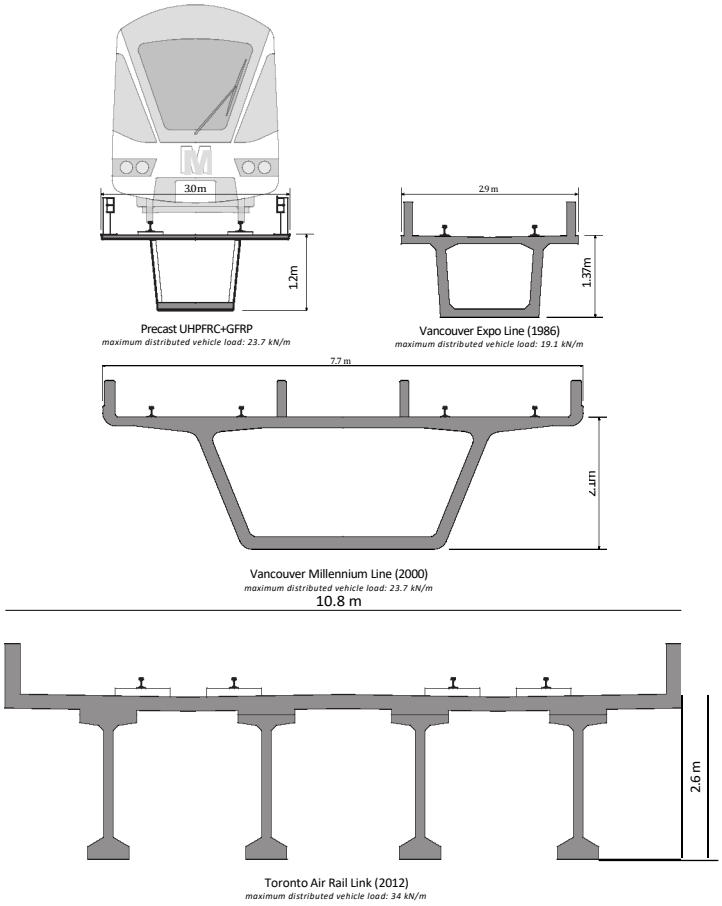
The goal of my research is the development of a new precast product: box girders made of ultra-high-performance-fibre-reinforced concrete (UHPFRC) acting compositely with glass-fibre-reinforced polymer (GFRP). The cross-section is shown in the upper left of the included figure. The webs of the box are stiffened GFRP panels, while the flanges are a two-layer composite of UHPFRC and GFRP. The top and bottom slabs of UHPFRC add stiffness, ductility and damping to the system.

For my dissertation I am specifically considering an application to elevated rail guideway structures. These structures are particularly suited to precast construction, due to the necessity to minimize construction work in the urban or suburban settings most common for transit projects. Furthermore, accelerated erection is desirable in the increasingly common case of a design-build-operate contract where earlier operation means earlier revenue flow.



Comparison of guideway cross-sections for 33-37 m spans

The potential benefit of this new precast product is best understood in the context of recent rail guideway construction in Canada. Precast, prestressed concrete box girders were used in the construction of the Vancouver Expo Line in the mid 1980's. These girders (top right cross-section in the figure) were made with custom forms of a modular design allowing for the fabrication of girders having a wide range of curvature and twist to accommodate track alignment requirements. Subsequent expansions of Vancouver's elevated transit system in 2000 and 2010 abandoned this system in favor of precast segmental construction (middle cross-section in the figure), despite the noticeable aesthetic advantages and superior material efficiency of the precast girder design.This switch was primarily related to difficulties in transporting and erecting the Expo Line's full-length concrete girders, each of which weighed around 100 tons and many of which had a cumbersome curved geometry. The recently completed AirRail Link in Toronto used precast girders with a cast-in-place deck (bottom cross-section in the figure). This is a well-established structural system in highway bridge construction, but by requiring a large quantity of cast-in-place concrete, it falls short of the full potential of precast technology to enable accelerated, minimal-impact on-site work. Further, supporting a curved deck on straight precast girders gives an aesthetic quality that would be inadequate for many urban transit projects.

The high strength and low weight of GFRP, coupled with the tensile strength, ductility, and stiffness of UHPFRC can allow precast guideway girders less than half the weight of the Expo Line girders. This lightness will amplify all of the construction benefits inherent in precast systems, and overcome the difficulties associated with the heaviness of the Expo Line girders. The result is a guideway girder system that provides all of the efficiency, slenderness, and constructional ease that is possible with precast technology.