Ask the EXPERT

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Q *Why Did the Laval Overpass Collapse?*

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A That is the question everyone is asking. At this time, unfortunately, too little evidence has been released to the public to be able to answer the question directly. There are many possibilities; however, given the age of the overpass and the environment it was in, a strong candidate for primary or contributing cause of the collapse is corrosion of the reinforcing steel contained within the concrete. A simplified discussion of this failure mechanism follows.

Most bridges and buildings constructed today, and for the past few decades, are composed of reinforced concrete. The reinforcement has, until recently, been provided by steel bars, also known as rebars or reinforcing bars. Steel cables may also be used. Material advancements over the past few years have brought non-metallic reinforcing products into view, to avoid corrosion problems. However, non-metallic reinforcements are, for the most part, still in the testing and development stage.

Reinforced concrete is stronger than unreinforced concrete: the reinforcing steel not only contributes to the concrete's compressive resistance but is also typically designed to carry all the tensile forces that occur in the concrete member. In a typical reinforced concrete beam supporting a bridge deck, the reinforcement positioned at the bottom of the beam would resist the tensile forces, and the concrete at the top of the beam

would resist the compressive forces within the beam. For the steel and concrete to work together as intended, the steel has to be bonded to the concrete that surrounds it. If that bond is reduced, or if the reinforcement is compromised, the load-carrying capacity of the reinforced concrete member is also reduced.

The most common cause of a reduced bond between the steel and the surrounding concrete is corrosion of the steel reinforcement. Steel, when it corrodes, creates a compound called "ferric oxide" or, more commonly, "rust." Rust occupies a greater volume than the original, uncorroded steel, so when the steel develops a thick enough layer of rust, the concrete around it cracks and moves away from the steel, thus losing its bond. Sometimes, chunks of concrete will spall off and fall to the ground. The corrosion also reduces the cross-sectional area, and thus the load-carrying capacity, of the reinforcement. If this occurs to enough of the steel, the bridge will eventually collapse under normal loads.

Corrosion of reinforcement is a problem in salt-rich environments, such as coastal areas and places that use road salt to control snow and ice in the winter. Quebec, like Ontario and other provinces, is a heavy user of road salt in the winter. Corrosion is also time-dependent: generally speaking, the older the bridge, the greater the corrosion. (The collapsed overpass was approximately 30 years old.)

Fortunately, most bridges, as well as other engineered structures, are designed to have a "safety factor" for greater-than-expected stresses and degradation. Typically, simply losing the bond between the concrete and some portion of

the reinforcement would not mean that a bridge would collapse under normal loads. However, if the problem is not rectified, and a greater amount of reinforcement corrodes, a sufficient loss of strength will eventually occur, resulting in a collapse. Regarding the Laval overpass collapse, there has been some concern about the construction quality itself, which has prompted transportation officials to close another overpass of the same vintage and built by the same contractor. It is possible that construction defects may have reduced the factor of safety intended for the bridge. If that is proven to be the case, corrosion could be the "straw that broke the camel's back" However, neither corrosion nor construction defects have been established to date.

Deteriorated reinforced concrete members are most commonly repaired by removing all loose concrete, sandblasting the steel and applying fresh concrete patches. This is essentially how the Gardiner Expressway in Toronto has been maintained. A proactive maintenance program, which includes scheduled inspections and repairs when required, can reduce the potential for disaster. In the matter of the Laval overpass collapse, it remains to be seen if corrosion and/or construction defects were the cause. If one or both were, it will likely bring into question the manner in which bridges in Quebec are inspected and maintained.

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