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Fatal Big Dig failure: ceiling anchors investigated

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ACCIDENT INVESTIGATORS were this week scrutinising the anchors suspending ceiling panels from the roof of Boston's troubled Big Dig tunnels after one panel fell last week, killing a woman.

The 3t reinforced concrete panel fell from the roof of the east bound tunnel of the Interstate 90 highway, which passes beneath Boston Harbour en route to Logan Airport, on Monday 10 July.

It smashed into a car in which Milena Del Valle was a passenger and crushed her to death.

The United States National Transportation Safety Board (NTSB) this week said that it was 'conducting detailed visual examinations and documentation of the remaining anchors of the same section of tunnel where the concrete ceiling panel collapsed'.

Pull tests were conducted this Monday 'to determine the characteristics of the epoxy which was used to secure the anchors in the ceiling of the tunnel', an NTSB spokesman confirmed.

Investigators said this week that bolts used to anchor hanger rods to the tunnel roof appeared to have pulled from their sockets and a further 250 bolts have shown signs of movement. .

The rectangular box section tunnel in which the failure occurred was constructed in reinforced concrete. Main contractor was Modern Continental, with project management by a joint venture of Bechtel and Parsons Brinckerhoff.

A ceiling consisting of 4m wide by 2m long, 3t reinforced concrete panels, was suspended between 1.5m and 2m below the tunnel roof. The void between roof and ceiling was used for tunnel ventilation.

The suspension system consists of T-shaped brackets bolted to the tunnel roof slab (see diagram). Holes were drilled into the slab and the anchor bolts grouted into place using epoxy resin.

Hanger bars approximately 1.5m to 2m long were bolted to the T-brackets. Longitudinal, upside down T-section beams were then suspended from the hanger rods to support the ceiling panel edges.

Investigations and remedial works could take months to complete, the NTSB added.

The ceiling panel collapse is the latest catastrophe to hit the Big Dig. Following completion in December 2004 a section of tunnel sprung a major leak (NCE 6 January 2005) and the project ran massively over budget and over schedule - costs soared from £3.6bn to £10bn.

British engineers this week said they were puzzled at the extent of the anchor failure problem being brought to light by investigations.

Problems with epoxy resin grouting are extremely rare, said Alan Clayton, technical service advisor at UK grout company Fosroc.

Clayton said that epoxy grouting is favoured on civil engineering projects because it is a reliable and tough way of securing anchors.

'It can take higher compressive loads than concrete, but also performs well under tensile and flexural loading, ' he said.

But he warned that it had to be properly applied. Epoxy resin is not an adhesive, but 'grips' deformations in the socket hole and anchor bolt. This means that the socket has to have a rough surface, or be underreamed, and that the anchor bolt must have a surface texture - typically a rebar type herringbone pattern or a conventional thread.

If anchor holes are cored from concrete using a diamond cutter instead of a conventional rock drill, the internal surface could be too smooth to provide a key for the resin, said Les Cheriton, a mining and tunnelling expert at chemicals supplier Minova.

There can also be problems if anchor bolts are smooth instead of textured shanks, he said.

But both insisted problems were most likely to stem from improper mixing of the resin with its activating chemical agent.

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