Fixing Failures – Case Study 3

School ceiling collapse – West Midlands 2007

An article for the
Construction Fixings Association

by Mark Salmon B Sc

of *Independent Fixing Consultants*
General Manager - CFA

This, the third case study in the "Fixing Failures" series, features a common application – suspended ceilings - and illustrates the difficulty of determining the cause of an accident while highlighting several aspects which we must consider in order to avoid similar accidents in the future. Nothing stated here is intended to imply a conclusion on the part of the CFA or the author as to the actual cause of the accident as there are various factors involved.

Background

In autumn 2007 a suspended ceiling, installed two years previously, collapsed in a classroom – fortunately while the room was empty. The ceiling was constructed of solid panels and would have caused serious injury had there been anyone underneath at the time. The panels were generally fixed within the main area of the ceiling with nylon hammer-in fixings and around the edges to a perimeter trim attached to the walls. The fixing of the ceiling panels to the edge trim was made with self tapping screws which, due to the particular detail of the design, were difficult for the fixer to locate accurately in the edge trim.

The fixings used

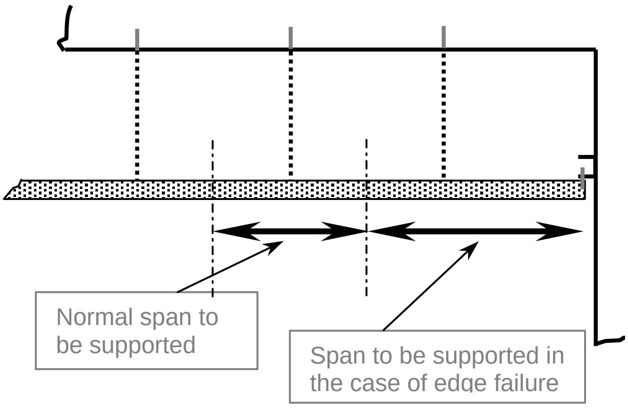
The ceiling was a plasterboard ceiling whose main area was supported by angle hangers fixed to a hollow core concrete ceiling by nylon hammer-in fixings of 6mm diameter and 40mm length.

The first line of these fixings was set at approximately 900mm from the wall. At the perimeter the edge trim was fixed using self tapping screws to channel sections fixed to the walls. The particular detail, requiring a gap between the edge of the ceiling and the wall, made the chosen fixing method using self tapping screws very awkward to achieve but this must have been obvious to the fixers who appear to have ignored the possible consequences.
The choice of nylon fixings in a ceiling is itself a mistake as they will have very little resistance in the case of a fire for which purpose all steel fixings would have been a better option. It is not clear whether or not the selection of the ceiling fixings was made by an engineer – it seems unlikely - but the specification should certainly have been approved by them. This appears not to have happened.

Possible causes of the failure

Following the failure, during which the whole ceiling came down, attention focussed initially on the possibility that it was the nylon hammer-in fixings that had failed. The time lag of two years between the installation and the failure lends credence to this theory as nylon fixings can be susceptible to creep which is normally avoided by the manufacturer quoting safe working loads based on large safety factors with respect to ultimate loads. Creep is explained below.

However, examination of the damage caused to the side walls suggested that there is every possibility that the collapse started at one edge and spread from there across the ceiling. Examination of the channel sections attached to the walls showed that in some cases the self tapping screws had passed through the very edge of the channel. Had these fixings failed then the first line of suspension hangers would have been required to support a far higher load than in normal service due to the distance from the wall being greater than half the normal span.



The normal span to be supported by each fixing is equal to the spacing between them but in the case of an edge failure the first line of fixings has to support any additional span if the line of fixings is further than half the normal spacing from the edge. Even the fact that any unsupported load at the edge of the structure will be at a significant bending moment means that additional fixings should be installed at the perimeter and in the first line of hangers.

Ceiling with first line of hangers set at less than half the normal span from each edge

Loads and fixing capacities.

The load to be supported by each of the main suspension hangers was reported to be in the order of 20kg.

To investigate the capacity of the hammer-in fixings the details of the fixings were requested along with samples for testing. Unfortunately no load data was available as the fixings had been supplied by a distributor from a wholesaler and were not of a recognised brand. The samples provided for testing, although from the same source, and supposedly carrying the same name, proved to be very different in form from those found in the debris. This itself raises a major issue. For incidents like this to be properly investigated the fixings used need to be fully identifiable but, due to the poor chain of supply, this proved not to be possible. Ideally the specification of fixings used, including full material specification and manufacturing processes should be traceable through factory production control systems to samples used in any testing programmes carried out to determine that fixings work properly and what their recommended loads are. This is what comes as standard with fixings which have been awarded European Technical Approvals which are now available on fixings for suspended ceilings[1], and on plastic i.e. nylon fixings[2].

Lessons to be learnt

In this case areas to be tightened up on are the design, the control of supply and the installation.

Design

With respect to the design this should be dome so as to ensure true redundancy by specifying additional fixings around the perimeter. One part of ETAG 001 – Part 6[1] is specifically designed for anchors to be sued tin this or other “Multiple use” applications such as pipework and is geared such that complicated calculations about redundancy can be avoided.

Supply

Distributors should give serious consideration to a policy of providing fixings which have been awarded ETAs for all safety critical applications as they provide a useful insurance policy in the case of accidents which will in any case be less likely with approved fixings.

Installation

In this case there was no evidence of bad practice with the fixings of the hangers but more care should have been taken with the self tapping screws. In all cases manufacturer’s instructions should be followed and where fixings are critical installers should be trained and supervised.

Creep

This is a phenomenon whereby an anchor may be capable of supporting a certain load during a short term test but may exhibit significant displacements and eventually fail when subjected to the same loads over a sustained period. It is usually avoided by the manufacture basing safe working loads on large safety factors with respect to the ultimate loads. Safety factors in the order of 7 to 1 are used by at least one Full Member of the Construction Fixings Association for nylon fixings in order to avoid the effect of creep.

[1] ETAG 001 Metal anchors for use in concrete. Part 6: Anchors for multiple use for non-structural applications. EOTA www.eota.be.

[2] ETAG 020 Plastic anchors for use in concrete and masonry for non-structural applications. EOTA www.eota.be.

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